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FLORIDA EVERGLADES

REPORT

OF THE

FLORIDA EVERGLADES ENGINEERING COMMISSION

TO THE

BOARD OF COMMISSIONERS OF THE
EVERGLADES DRAINAGE DISTRICT AND
THE TRUSTEES OF THE INTERNAL
IMPROVEMENT FUND

STATE OF FLORIDA
1913

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

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SUBMITTED BY MR. FLETCHER.

IN THE SENATE OF THE UNITED STATES,
January 29, 1914.

Ordered, That the report of the Florida Everglades Engineering Commission to the board of commissioners of the Everglades drainage district for 1913 be printed as a Senate document with accompanying illustrations.

Attest:

JAMES M. BAKER, *Secretary.*

Agric. Dept.

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LETTER OF TRANSMITTAL.

FLORIDA EVERGLADES ENGINEERING COMMISSION,
Miami, Fla., October 25, 1913.

To the board of commissioners, Everglades drainage district, and the trustees of the Internal Improvement Fund, State of Florida: Hon. Park Trammell, governor, ex officio president; Hon. W. V. Knott, comptroller; Hon. J. C. Luning, State treasurer; Hon. T. F. West, attorney general; Hon. W. A. McRae, commissioner of agriculture.

GENTLEMEN: I transmit herewith the report of the Florida Everglades Engineering Commission prepared in accordance with certain articles of agreement between yourselves and myself made and entered into on the 30th day of April, 1913.

The first article of said agreement is that I, "The engineer, shall organize a board of engineers to be known as the Everglades Engineering Commission (hereinafter referred to as the Engineering Commission). That the said commission shall consist of Isham Randolph, who shall be chairman, Marshall O. Leighton, representing the J. G. White Engineering Corporation, and Edmund T. Perkins."

The commission called for by this clause of the contract was promptly organized and appropriate work assigned to its respective members.

Mr. M. O. Leighton undertook the hydrometric investigations, a work for which he is particularly well equipped, and Mr. Edmund T. Perkins undertook the surveys and mapping operations, duties for which he was exceptionally well qualified. We established headquarters in Miami May 3, 1913. The first secretary of the commission was Mr. George C. Pierce, who served efficiently and satisfactorily until June 28, when he left the service of the commission and was succeeded by Mr. George B. Hills, who had previously, until that date, been in charge of one of the survey parties employed by the commission. The conclusions and recommendations of the commission and the reasons upon which they are based and by which they are supported are given in the following report, which is accompanied by maps and plans.

I wish to here record my high appreciation of the work done by my associates and the loyal spirit in which they have cooperated with me to make this report as comprehensive and conclusive as was possible within the limits of time imposed upon us and the pecuniary resources at our command.

Respectfully submitted.

ISHAM RANDOLPH, *Chairman.*

UNIV. OF CALIFORNIA

FLORIDA EVERGLADES.

FLORIDA EVERGLADES ENGINEERING COMMISSION,
Miami, Fla., October 25, 1913.

To the board of commissioners, Everglades drainage district, and the trustees of the Internal Improvement Fund, State of Florida: Hon. Park Trammell, governor, president ex officio; Hon. W. V. Knott, comptroller; Hon. J. C. Luning, State treasurer; Hon. T. F. West, attorney general; Hon. W. A. McRae, commissioner of agriculture.

GENTLEMEN: The Everglades Engineering Commission submits this report upon the practicability of draining the Everglades, and recommendations as to the methods by which said drainage may be accomplished.

Our conclusion, based on our study of ascertained facts, is that the drainage of the Florida Everglades is entirely practicable and can be accomplished at a cost which the value of the reclaimed land will justify, the cost per acre being very small.

The solution of the Everglades drainage problem is primarily dependent upon the disposition to be made of the flood waters entering Lake Okeechobee from the north. These flood waters under present conditions pass over the south rim of the lake and spread over the Everglades, placing that great area under servitude of the surplus waters of the northern watershed. In our judgment the Everglades can best be relieved of this servitude by diverting the flood waters through a canal of adequate capacity occupying the shortest practicable route to the Atlantic Ocean or an inlet thereof. Such a canal we indicate upon our maps and report upon its dimensions and its probable cost. With these extraneous flood waters diverted as indicated, the problem of draining the Everglades is reduced to proper provision for carrying off the precipitation upon them. This can be accomplished by adding to the main canals which now traverse this territory—canals now surcharged with waters flowing out of Lake Okeechobee—other canals, the courses of which are indicated on the maps accompanying this report and herein described and recommended.

Here we inject our recommendation that the whole cost of the Okeechobee-St. Lucie Canal be not charged against the draining of the Everglades, because this canal will serve three purposes: First, to control the level of Lake Okeechobee for land drainage and flood storage; second, to provide a 12-foot navigable canal, comparable in capacity with the New York Barge Canal, to construct which that State is now spending $108,000,000; third, to afford a water power of primary capacity of 5,000 horsepower which will return to the drainage district an income that will contribute largely toward the future maintenance of the drainage systems. The total cost of this canal, lock system, and power plant is estimated at $2,500,000. We believe that this investment charge should be divided approximately into three equal parts; one part to be assessed against the drainage district, another against navigation, and the third to be bonded separately against the water-power plant. We believe that the water power will justify a bond issue of about $900,000, representing an investment of $180 per horsepower. In the south Florida region, where power will be in increasing demand for commercial and household purposes, for pumping water for irrigation, and in the earlier periods for operating dredges in interior drainage operations, will surely find a profitable market. Present and prospective cost of fuel in that region is high; therefore power derived from fuel will also be of large cost. We believe that a gross average selling price of $40 per horsepower year for 24-hour power is conservative under all prevailing conditions. Thus there is promised an annual income of $200,000, which, however, does not include the possible increase in actual sales equivalent to 40 or 50 per cent in excess of actual plant capacity. This is commonly made possible by the fact that consumers do not use power continuously nor at the same periods of the day. Consequently, a market 40 or 50 per cent in excess of plant capacity may usually be supplied The added income thus derived will surely cover all cost of administration and possibly a part of the operation costs.

Fixed charges against this plant, exclusive of transmission system, will not exceed 10 per cent on the investment, or $90,000 annually. The residue of the annual gross income $110,000 plus the excess income above referred to should care for all operative charges and leave a generous balance which can be applied to future drainage district maintenance.

Having made the foregoing broad declaration of our conclusions, we will give in detail the ascertained facts on which these conclusions are based.

First, however, we wish to enter our appreciative acknowledgment of information and aid extended to us by the gentlemen hereinafter named:

Hon. David F. Houston, Secretary of Agriculture.
Beverly T. Galloway, Assistant Secretary of Agriculture.
S. H. McCrory, Office of Experiment Stations, United States Department of Agriculture.
O. H. Tittmann, Superintendent Coast and Geodetic Survey.
George Otis Smith, Director United States Geological Survey.
R. B. Marshall, chief geographer, United States Geological Survey.
E. P. Davis, topographer, United States Geological Survey.
J. R. Slattery, major, Corps of Engineers, United States Army.
J. E. Ingraham, vice president Florida East Coast Railway.
E. Ben Carter, superintendent maintenance of way, Florida East Coast Railway.
W. J. Krome, constructing engineer, Florida East Coast Railway.
V. W. Helm, president Everglades Land Sales Co.
J. W. Kackley, chief engineer, Everglades Land Sales Co.
John T. Stewart, professor of agriculture, University of Minnesota.
Hon. W. S. Jennings.
F. C. Elliot, acting chief drainage engineer.
Capt. J. L. Megathlin, of Furst-Clark Construction Co.

Prof. Charles F. Marvin, Chief, United States Weather Bureau.
Dr. Lyman J. Briggs, physicist, Bureau of Plant Industry.
J. L. Porter, director, New Orleans water filtration plant.
George C. Earl, general superintendent, New Orleans sewerage and water board.
Biscayne Engineering Co. of Miami, Fla.
Dr. J. N. McGonigle, president, Miami Water Co.

CONDITIONS.

The conditions which existed when the Everglades Engineering Commission entered upon its duties as defined in the contract of April 30, 1913, are:

Lake Okeechobee, the great liquid heart of Florida, which, with the exception of Lake Michigan, is the largest body of fresh water wholly within the United States, lies at the focus of the greatest agricultural drainage problem in our country. This basin receives, to the limit of its capacity, the floods from a watershed 5,366 square miles in area. When that capacity is exceeded, the excess waters spill over its southern edge and flow southward over an area of 4,000 square miles known as the Florida Everglades, stretching away from the lake to the southern coast of the State. One canal, known as the Three-mile Canal, flowed westward into Caloosahatchee River; two canals had been dug through from the lake to waters discharging into the Atlantic, and a fourth was, and is, in process of construction. These canals are the South New River and Miami Canal, now designated as the Miami Canal and the North New River Canal. Through the full length of each canal there was a shallow navigation, but a large amount of rock has yet to be excavated from the Miami Canal to obtain the depth called for by the plans. These two canals were connected by a channel running east from the Miami Canal, which discharges into New River a short distance from where that stream receives the discharge of the North New River Canal. This east-west canal is now called the South New River Canal. The canal, then and now, in process of construction is known as the Hillsborough Canal. Though it has as yet no excavated outlet, it is discharging from Lake Okeechobee into the Everglades, about 400 cubic feet of water per second.

These canals, the initial part of a progressive drainage system, work on which is still progressing, under present conditions, even in so dry a season as that which has obtained for several months past, now serve to keep the Everglades wet because they are surcharged with Lake Okeechobee waters. This condition will not obtain when the whole project is carried out. The present canals will, as a part of a broad comprehensive system, be worth to the State every dollar that they have cost. They are there to serve a useful purpose in the great scheme of reclamation upon which the State has embarked; a scheme which has only to be carried to completion to make fertile fields of a watery waste and a populous land where now no man dwells.

PROGRESSIVE DRAINAGE.

We have encountered an idea, which if not generally prevailing is, at least, entertained by a large number of intelligent citizens of Florida to the effect that the problem of draining the Everglades can not be solved by progressive steps, but that the whole area must forthwith be covered by a great interdependent system of canals. We believe this to be an erroneous idea, and that the Everglades can be reclaimed progressively, as is now planned by your board; that the work can so proceed as to reclaim the lands only as fast as there is need for those areas as homesteads and food producers. We regard Lake Okeechobee as the key to the solution of the whole problem. When that great reservoir is brought under control and the territory to the south is freed from the overflow of the lake, then the emancipated region can be relieved by adequate main drainage outlets and subsidiary canals whose capacities may be adjusted to meet the needs of the territory which they serve.

SURVEYS OF LAKE OKEECHOBEE, THE EVERGLADES, AND THE TERRITORY EMBRACED IN THE DRAINAGE DISTRICT ESTABLISHED BY ACT OF LEGISLATURE OF FLORIDA OF 1907, CHAPTER 5709.

Article 2 of the agreement between the board of drainage commissioners and Isham Randolph, engineer, provides that the Florida Everglades Engineering Commission shall procure and study all data, facts, information, and physical conditions affecting Lake Okeechobee, the Everglades, and all territory embraced in said drainage district, by personal reconnaissance of the territory embraced by Lake Okeechobee, the Everglades, and their watersheds.

Article 3 provides that the Florida Everglades Engineering Commission shall cause to be made such further surveys as may be necessary for its use in preparing recommendations for approximate location of canal routes and making the estimates of the cost of the construction of such works as they may recommend in said report.

Article 4 provides that the Florida Everglades Engineering Commission shall cause a map to be made of the area embraced within the scope of said investigations as nearly accurate as may be determined from the data, facts and information to be obtained, and shall show thereon, as far as may be by conventional signs, the ascertained facts and things to be done as recommended in said report, and the conventional signs shall be supplemented by such notes as may be appropriately entered upon said map.

Personal reconnaissance.—The Atlantic Coast Line from Detroit on the south to Stuart on the north, has been traversed by train, boat, automobile, horse, conveyance, and on foot and studied with all available data in hand. The Everglades themselves have been traversed via the Miami, North New River, and Hillsborough Canals.

Caloosahatchee River and the lakes and canals connecting it with Lake Okeechobee were examined as far west as Fort Myers, and Kissimmee River, from Kissimmee to Lake Okeechobee, was investigated.

Lake Okeechobee was accurately mapped for the commission and at its expense by the United States Geological Survey. This map is officially adopted by said Geological Survey, was searchingly studied and has formed the basis of many of our conclusions.

Particular investigation and study was made of the territory between Lake Okeechobee and along the Atlantic, north and south from Lake Worth to St. Lucie River.

Procurement of data.—In accordance with the terms of the agreement, the drainage board placed at the disposal of the commission all data of which it was possessed bearing upon the matters covered by the investigation, in the form of maps, charts, printed or manuscript reports. Acknowledgment is here made of the willing assistance at all times rendered the commission by your board and its engineers.

In Appendix A (see p. 89) is a list of the maps, charts, etc., received from the drainage board from the Secretary of Agriculture, the superintendent of the United States Coast and Geodetic Survey, the Director of the United States Geological Survey, the Florida East Coast Railroad, the Everglades Land Sales Co., Prof. John T. Stewart of the University of Minnesota, formerly of the United States Department of Agriculture, and many others.

The district commissioners and this engineering commission must be considered especially fortunate in having been provided with so much information, much of which has never before been made public.

Surveys.—Realizing the prime necessity of prompt action, the engineer, immediately upon the execution of the agreement, organized two survey parties. One, the northern survey, under the direction of George B. Hills, carried a transit line, with levels, from the Atlantic Ocean to Lake Okeechobee, via Loxahachee Slough. Through the faithful and intelligent efforts of the men of the party and their chief, this work was most successfully accomplished and physical difficulties were overcome which had previously frustrated all efforts in this direction. The work of this party was particularly valuable in locating the position of Lake Okeechobee with reference to the geodetic positions of the United States Coast and Geodetic Survey on the Gulf and Atlantic coasts, in furnishing a check upon the profiles developed farther north, and in establishing the most important negative fact that this locality was essentially not the right location for a control canal for Lake Okeechobee. The surveys of John T. Stewart, of the Department of Agriculture, and of the drainage board had already established the undesirability of a control canal from Lake Okeechobee to either Loxahachee Slough or to Jupiter Inlet.

The second organization, the southern survey, consisted of two parties under the general supervision of J. B. Phinney, assisted by J. A. Moore. Its particular function was to establish the southern limit of the Everglades on the south, beyond which reclamation is at present impracticable on account of the prevalence of salt or brackish water. The main party ran a transit and level line from tidewater on the Atlantic at the east end of the Detroit Canal to tidewater on the Gulf of Mexico at the south of Hammer Key. The auxiliary party ran "offsets" at intervals north and south until satisfactory information was obtained concerning the limits of fresh and salt water in the south end of the Everglades.

When the northern and southern surveys had completed their allotted tasks, the southern crew was disbanded and Mr. Moore put in charge of the northern survey party and assigned to work on the west edge of the Everglades in the Big Cypress Swamp.

Accepting the location and elevations of the Department of Agriculture at Brown's store as correct, a transit and level line was run southwest to Chokoloskee Bay. The object of this survey was to define the territory tributary to the Everglades and to locate the drainage divide on the west. The information obtained was important, but entirely negative. It was found that the direction of drainage was indeterminate and variable, depending upon the height of water, prevailing winds, density of growth on the prairies and in the channels, and other local conditions which changed with the seasons and the years.

The most important survey was that of Lake Okeechobee in cooperation with the United States Geological Survey, arranged for by Mr. M. O. Leighton. This survey, on a scale of 1 inch per 1 mile, was the work of E. P. Davis, topographer, United States Geological Survey. The resulting map shows the outlines of the lake and the 16 and 20 foot contours, above mean low water, Gulf of Mexico. This map is the first complete and accurate map of Lake Okeechobee. It shows the greatest lengths of the lake north and south to be 37 miles, east and west 31 miles, and the shore line of the lake, at the time of the survey, to be 135 miles. The area of the water surface at 20 feet above gulf is 730 square miles; at 19 feet it is 725 square miles; and at 16 feet, 710 square miles. The arrangement with the United States Geological Survey for cooperation was most satisfactory. It permitted the State to use the instruments and equipment of the Government as well as the skilled services of its expert engineers, the State paying only actual salaries and expenses. The resulting work carries all the prestige of Government for accuracy.

Cooperation, like that above mentioned, between the State and Government might advantageously be established for the following surveys, which the commission regards as essential before the definite plans for reclaiming the Everglades are put into effect:

First. A line of precise levels should be run from mean low water on the Gulf of Mexico to mean low water on the Atlantic Ocean, and geodetic control established along this line either by triangulation or by primary traverse. This survey is essentially a duty of the United States Government and your representatives in Washington should take immediate steps to have it made by either the Coast and Geodetic or the Geological Survey, both of which organizations are equipped with men and instruments for such surveys.

Second. A topographic map on a scale of 1 mile to 1 inch with contour intervals of 2½ and 5 feet should be made from Stuart southwest to the east shore of Lake Okeechobee, covering all territory through which it might be possible to construct the control canal. This work could be done in cooperation with the United States Geological Survey, but in consideration of its pressing necessity and the fact that the territory to be mapped does not correspond to the latitude and longitude boundaries of Geological Survey atlas sheets, it would appear best for it to be immediately undertaken by other agents. Simultaneously, borings should be made to establish soil conditions over the several alternate routes of the control canal.

Third. A hydrographic chart of the St. Lucie River, showing shore outlines and depths of water from the inlet to the head of South River should be made, in cooperation with either the Coast and Geodetic Survey or the Hydrographic Office.

Appendix B (see p. 90) is a list of tide gauges upon the Atlantic and Gulf coasts as furnished by the United States Coast and Geodetic Survey.

Appendix C (see p. 103) is a list of bench marks of the Florida Coast Line Canal as furnished by the United States Army Engineers. These tide gages and bench marks should be connected by level lines.

Maps.—In addition to the map of Lake Okeechobee, made in cooperation with the United States Geological Survey, the commission has caused to be compiled two maps, viz:

1. *Florida, south of latitude 28° 30′.*—A polyconic projection was constructed for the parallels 24° 30′ to 28° 30′ and meridians 80° to 83° on a scale of 1:380,160 (6 miles = 1 inch) showing the meridians and parallels at intervals of 30′, using for the construction of this projection the tables of the United States Coast and Geodetic Survey. Upon this projection was transferred Coast and Geodetic charts Nos. 162 to 167, inclusive, and 173 to 178, inclusive, so that the exterior parts of the territory mapped are accurately located, but only these parts. Within these meridians was compiled the information carried on the latest maps of the General Land Office, the Post Office Route Map, the United States Geological Survey map of Florida, the United States Army Engineer charts, and other maps of the area under investigation, giving to each map such weight as its proved accuracy justified, so that the resulting map is as nearly accurate as may be determined from the available data. It must at all times be understood that information does not exist for the making of a map geodetically correct.

On this map are shown, by conventional signs, the ascertained facts and a general plan of works recommended in this report. These works are also shown in detail by conventional signs on the second map, which is:

2. *Lake Okeechobee section—Florida Everglades.*—This map is constructed on a scale of 1:63,360 (1 mile = 1 inch), and includes the area between parallels 26° 33′ N. to 27° 20′ N., and meridians 80° W. to 81° 10′ W., showing the meridians and parallels at intervals of 10 feet. On it is placed all information contained on the map previously described and such additional data as this larger scale permits, the same sources of information being used. On prints of this map are shown in detail the things recommended in this report. The conventional signs of the map are supplemented by approximate notes entered thereon. These details are entered on separate prints instead of the original maps because it is expected that the latter will serve as a base or mother map from which prints may be made for future uses.

CANALS.

Article 3 of the contract provides that "such canals and works incident or necessary thereto to be shown on said plans * * * shall be sufficient in number and capacity to provide the system of main canals required to drain the land area embraced within said drainage district, so far as the same may be accomplished without resorting to pumping the water from the land and that will be sufficient to relieve the land aforesaid of all surface water, but the said report shall not deal particularly with minor subdivisions of land. Farm ditches are not to come within the purview or scope of said report."

Main canals are defined as being the canals carrying the water of the drainage district and its watershed to some major body of water.

MAIN CANALS.

At present there have been excavated as main canals the North New River, South New River, and Miami Canals. Those under construction are the Cypress Creek, Snake Creek, Snapper Creek, and Hillsborough Canals. Contract has been let for the West Palm Beach Canal.

Until completed as planned this system of main canals will not wholly accomplish the purpose of reclamation, but after the construction of the Lake Okeechobee-St. Lucie Canal it will not be unreasonably expensive to so increase its capacity that it will suitably drain a major portion of the drainage district.

The existing system of canals contemplates the reclamation of a greater portion of the Everglades in the immediate future than will probably be justified by the demand for new lands. It would have been much better to provide for an orderly progression of reclamation in accordance with the demand and with due regard to market conditions and transportation facilities. The existing works and the conditions of land, ownership and settlement, seems now to be such as to necessitate an earnest effort to reclaim in one continuous project and with the greatest possible expedition all the lands south and southeast of Lake Okeechobee, between the Miami Canal, the proposed West Palm Beach Canal, and the eastern boundary of the drainage district.

Moved by these considerations, the commission has endeavored to plan such a system as will permit the State to provide adequate main canal drainage for this territory.

The larger project may naturally be divided as follows:

1. Between south shore of Lake Okeechobee-Miami Canal, Hillsborough Canal, and eastern boundary of drainage district.
2. Between Miami and Detroit.
3. Allapattah Flats, in northeast portion of drainage district.
4. In northwest corner drainage district, beyond Lake Okeechobee.
5. South and west of the Miami Canal, to the south and west boundaries of the district.

The proposed scheme provides—

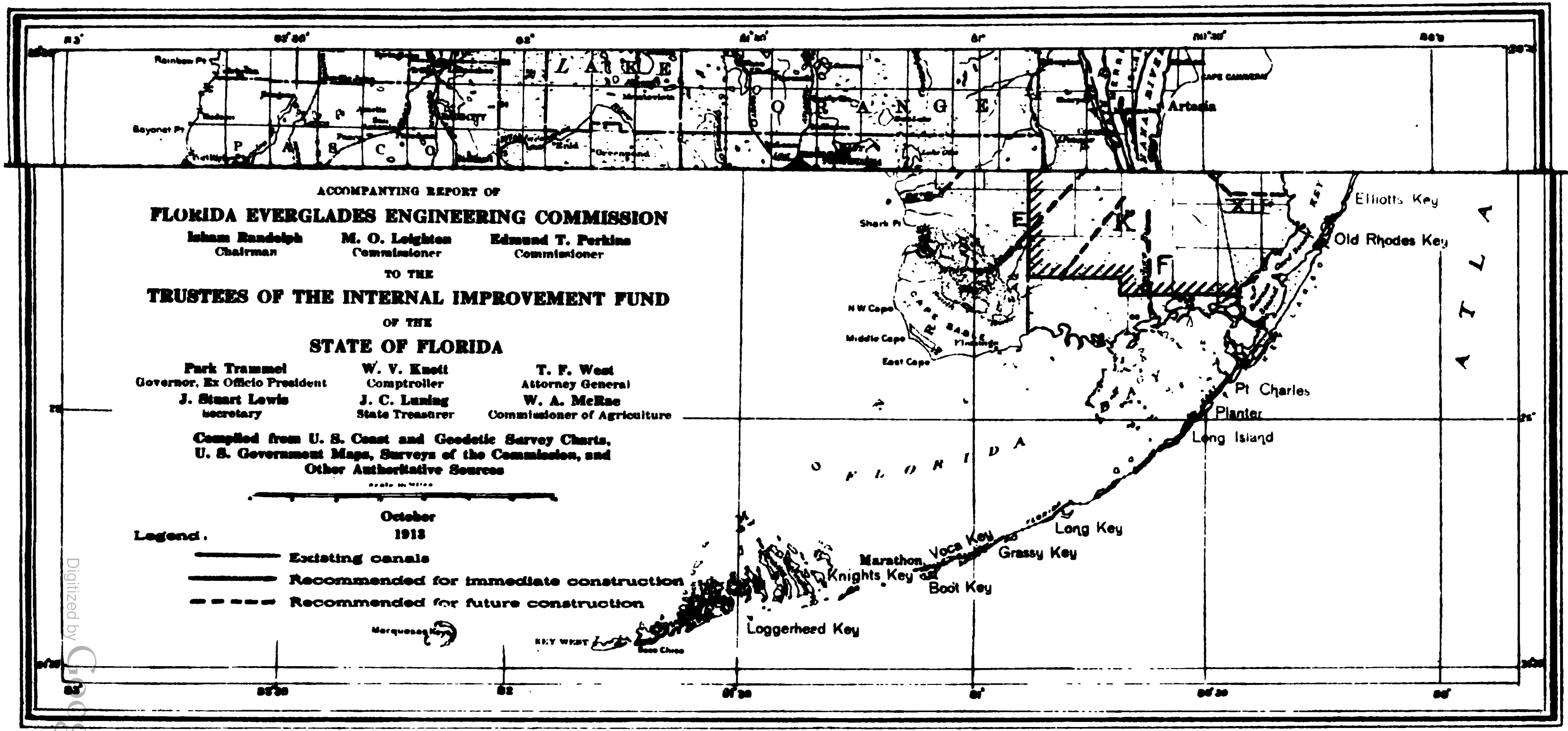
(*a*) That the drainage capacity of the Hillsborough Canal be supplemented by the construction of the canal marked VIII on the map, beginning at a point midway between the West Palm Beach Canal, and the Hillsborough Canal about 10 miles from Lake Okeechobee and running southeast about 33 miles to the Hillsborough Canal at the eastern edge of the district. The final capacity of this canal should be sufficient to reclaim 340 square miles.

(*b*) That from a point midway between the Hillsborough Canal and the North New River Canal about 9 miles southeast of Lake Okeechobee, a canal marked IX on the map shall be constructed southeast, emptying into the Cypress Creek Canal enlarged, a total length of 32 miles, designed to drain 240 square miles.

(*c*) That from a point midway between the Miami Canal and the North New River Canal about 25 miles south of Lake Okeechobee a canal marked X on the map shall be constructed southeast, crossing the South New River Canal, to connect with the present Snake Creek Canal. This canal must be designed to drain 429 square miles.

(*d*) The present Snake Creek must be enlarged from this point of connection to the Atlantic Ocean to carry the drainage from a territory of over 400 square miles.

(*e*) When the foregoing canals have been constructed, those already in existence or contracted for will have the following duties imposed upon them: The Miami Canal, from the lock 9.1 miles south of Lake Okeechobee to the Miami River will drain an area 1.5 miles on either side, a total area of 216 square miles. The North New River Canal, from the lock 8.75 miles south of Lake Okeechobee to New River



ACCOMPANYING REPORT OF

FLORIDA EVERGLADES ENGINEERING COMMISSION

Isham Randolph Chairman	**M. O. Leighton** Commissioner	**Edmund T. Perkins** Commissioner

TO THE

TRUSTEES OF THE INTERNAL IMPROVEMENT FUND

OF THE

STATE OF FLORIDA

Park Trammel Governor, Ex Officio President	**W. V. Knott** Comptroller	**T. F. West** Attorney General
J. Stuart Lewis Secretary	**J. C. Luning** State Treasurer	**W. A. McRae** Commissioner of Agriculture

Compiled from U. S. Coast and Geodetic Survey Charts, U. S. Government Maps, Surveys of the Commission, and Other Authoritative Sources

Scale in Miles

October
1913

Legend.

- Existing canals
- Recommended for immediate construction
- Recommended for future construction

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will drain an area of 190 square miles. The Hillsborough Canal, from the lock 12 miles southeast of Lake Okeechobee, will drain 186 square miles. Cypress Creek Canal must be enlarged to carry the drainage of 240 square miles.

By reason of the above-mentioned locks and the construction of the canal marked "VII" on the map, there is turned into Lake Okeechobee from the south and east the drainage of 500 square miles. Canal VII will be constructed from the west center line of township 44 south, range 33 east, in a northeasterly direction 12 miles to Lake Okeechobee, and is designed to drain 106 square miles of territory.

(*f*) From Miami to Detroit there is a strip of land, approximately 10 to 12 miles wide, tributary to the Atlantic Ocean. For main canals in this territory it is believed that the present Snapper Creek Canal, with the construction of canals marked "XI" and "XII" on the map, will suffice. Canal XI extends from about the center of township 55 south, range 39 east, in a southwesterly direction 10 miles into Biscayne Bay, draining 65 square miles. Canal XII extends from the south center of township 56 south, range 38 east, in a southwesterly direction 7.5 miles to the Detroit Canal, draining 72 square miles. The Detroit Canal is private property, but arrangements should be made by the State to acquire it and enlarge it to complete canal XII to Biscayne Bay. Provision is made for extending Snapper Creek Canal to the west across the Everglades to the west center of township 54 south, range 35 east, as a part of the progressive development of the future.

(*g*) The Allapattah Flats in the northeast corner of the drainage district are to be drained by a canal marked "V" on the map, running from the northern edge of the drainage district in township 37 south, range 38 east, in a southeasterly direction 23.5 miles to the Okeechobee–St. Lucie Canal, designated "VI" on the map. Canal V is designed to drain 195 square miles; canal VI is designed not only to carry a minimum of 5,000 second feet of water for control of water level in Lake Okeechobee and for power purposes, but also the drainage of canal V, which will drain 75 square miles.

(*h*) The northwest corner of the drainage district beyond Lake Okeechobee presents an isolated problem and is, in itself, an illustration of the fact that it is possible to economically drain fractional portions of the Everglades. Canal I, beginning in the northwest corner of the drainage district and running due south 24 miles to Fisheating Creek, is designed to drain 50 square miles of territory. The spoil from this excavation should all be deposited in the form of a levee on the west. This levee and the canal itself will prevent overflow from the lands west of the district. Canal II, projected from the northwest corner of the drainage district, due east 16 miles into the Kissimmee River, and is designed to drain 49 square miles. It will also protect the lands of the district from overflow from the north. Canal III, running from the southeast corner of township 37 south, range 31 east, 14.5 miles to the shore of Lake Okeechobee, is designed to drain 200 square miles. Canal IV provides for a canalization of Fisheating Creek for 9.5 miles and is designed to carry the water of 740 square miles of territory.

(*i*) In the future, as the lands in parts 1 and 2 are reclaimed, settled, and cultivated, it will be necessary to extend the canal system to the west and south, and suggestions, of course, which take advantage of all information obtainable as to the elevations and natural channels, are here made. It is impossible now to determine precisely the most advantageous method of making such extensions, for this will be dependent upon the settlement and development of the areas first reclaimed.

It is suggested that the canal A in the western part of the district might start at the lock at the end of canal VII and continue southwest of the line between ranges 32–33 east, thence south past Glade Cross Mission and the Seminole Indian Reservation and across the eastern branch of Okaloacoochee Slough to the headwaters of Turner River and down Turner River to Chokoloskee Bay. Such a course will protect the west edge of the drainage district from overflow from the Big Cypress Swamp, and form a direct and short connection from Lake Okeechobee to the Gulf.

Canal B should be constructed from a point on the Miami Canal about 25 miles south of the lake, thence south of west to the west center of township 52 south, range 35 east, thence to Chatham River.

Canal C should start from canal B in the west center of township 52 south, range 35 east, and run south 12 miles, thence southwest to Lossman River.

Canal D begins at canal E in the southeast corner of township 55 south, range 36 east, and extends 8.5 miles west, thence southwest to the inlet from the Gulf of Mexico.

Canal E should run south from the junction of Miami Canal in township 49 south, range 37 east, to southeast corner of township 56 south, range 36 east, thence southwest into White Water Bay.

Canal F begins east of Royal Palm Key and runs approximately south into Taylor River.

Canal G is designed to connect canals A and B through the eastern branch of Okaloacoochee Slough.

Canal H should extend east from junction of canals B and C at west center of township 58 south, range 35 east, to the Miami Canal.

Canal I runs east 11 miles from east center of township 56 south, range 36 east.

Canal K is planned to extend southwest from south shore of Royal Palm Key to salt water, about the east center of township 59 south, range 55 east.

Canal L runs east and west between Miami Canal and canal A in the north part of township 47 south.

The South New River Canal is to be extended west to reach canal B.

Snapper Creek Canal is to be enlarged and extended west to reach canal C. It is believed that the system of main canals above traced will be sufficient to reclaim this part of the drainage district; but where this extension will begin will be dependent upon conditions as they develop.

ESTIMATE OF COST.

Assuming $n=0.035$; side slope 1:1; $s=0.3$ foot per mile$=0.00057$ and the water surface 3 feet below present ground surface, the total quantities and costs in thousands for the various parts of the project are as follows for 0.6 inch run-off per day:

1. BETWEEN SOUTH SHORE OF LAKE OKEECHOBEE, MIAMI CANAL, HILLSBOROUGH CANAL, AND EASTERN BOUNDARY OF DRAINAGE DISTRICT.

(A) ADDITIONAL CANALS.

Canals.	Length.	Area drained.	Cubic yards excavation.	Unit cost.	Total cost.
	Miles.	*Sq. mi.*		*Cents.*	
VIII	33.00	340	7,078,000	9	$637,000
IX	42.00	242	7,844,000	10	784,000
X	61.00	429	15,510,000	10	1,551,000
Total	136.00	1,011	30,432,000	....	2,972,000

(B) ENLARGEMENTS, PRESENT CANALS SOUTH OF PROPOSED LOCKS.

West Palm Beach	32.00	96	(1)	....	....
Hillsborough	38.00	186	500,000	12½	....
North New River	47.00	190	1,800,000	12½	....
South New River	24.00	72	1,450,000	12½	....
Miami	72.00	216	4,650,000	12½	....
Total	213.00	760	8,400,000	....	$1,050,000

(C) ENLARGEMENTS, PRESENT CANALS NORTH OF PROPOSED LOCKS.

West Palm Beach	12.00	69	(1)	....	....
Hillsborough	12.00	59	795,000	10	....
North New River	8.75	105	344,000	10	....
South New River	9.1	91	433,000	10	....
Total	41.85	324	1,572,000	....	$157,200

[1] Sufficient as at present designed.

(d) Four standard locks, at $25,350, $101,400.

A grand total of 390 miles of canal, draining 2,095 square miles, or 1,341,000 acres, at a total cost of $4,281,000, or $3.20 above present expenditures.

To this cost per acre must be added the cost per acre to the entire district for one-third of the expenditures on the Lake Okeechobee-St. Lucie Canal, which is as follows:

Excavation for canal	$2,182,990
Locks	48,060
Dam	18,467
Excavation for locks and dam	9,014
	2,259,000

or 22 cents for each of the 3,372,000 acres of the drainage district benefited by this canal. The acreage benefited is estimated by deducting from the 4,000,000 acres of the district 464,000 acres, the surface of Lake Okeechobee at elevation 19, and 164,000 acres between Miami and Detroit, which this canal does not affect.

Canal VII is just west of this territory. Its 12-mile length drains 106 square miles of territory, or 68,000 acres, with an excavation of 2,500,000 cubic yards of muck, estimated to cost $150,000, or $2.20 per acre, a total of $2.76, including Lake Okeechobee-St. Lucie Canal,

2. BETWEEN MIAMI AND DETROIT.

Canals.	Length.	Area drained.	Cubic yards excavation.	Unit cost.	Total cost.
	Miles.	*Sq. miles.*		*Cents.*	
XI	10.00	63	1,656,000	12½	....
XII	7.50	72	1,468,000	12½	....
Detroit	9.00	108	1,616,000	12½	....
Snapper Creek	6.00	13	160,000	12½	....
	32.50	256	4,900,000	....	$613,000

or 164,000 acres, at a cost of $3.70 per acre for main canals.

3. ALLAPATTAH FLATS IN NORTHEAST PORTION OF DRAINAGE DISTRICT.

Canal V is 23.5 miles long, drains 195 square miles of territory, with an excavation of 6,188,000 cubic yards of muck, estimated to cost $372,000, or for 125,000 acres $2.95 per acre, a total of $3.51 per acre,

4. NORTHWEST CORNER DRAINAGE DISTRICT BEYOND LAKE OKEECHOBEE.

Canals.	Length.	Area drained.	Cubic yards excavation.	Unit cost.	Total cost.
	Miles.	*Sq. miles.*		*Cents.*	
I	24.00	50	2,565,000	6	....
II	16.00	49	1,625,000	6	....
III	14.50	197	3,704,000	6	....
IV	9.50	(740)	4,013,000	6	....
	63.00	296	11,907,000	....	$714,420

or 192,000 acres, at a cost of $3.71 per acre, a total of $4.27.

These computations make the cost per acre above present obligations $3.64 for 1,890,000 acres, and for the remaining district as follows:

5. SOUTHERN AND WESTERN PORTIONS OF DRAINAGE DISTRICT.

Canals.	Length.	Area drained.	Cubic yards excavation.	Unit cost.	Total cost.
	Miles.	*Sq. mi.*		*Cents.*	
A	62.0	673	20,090,000	20	$4,018,000
B	55.0	555	20,651,000	20	4,130,200
C	32.0	316	7,447,000	20	1,495,400
D	31.0	252	3,788,000	20	757,600
E	27.0	175	5,274,000	20	1,054,800
F	8.5	120	1,316,000	20	263,200
G	17.5	126	2,710,000	20	542,000
H	21.0	106	1,205,000	20	241,000
I	9.0	88	971,000	20	194,200
K	9.0	66	866,000	20	173,200
L	18.0	209	2,858,000	20	571,600
South New River	17.0	63	1,636,000	20	327,200
Snapper Creek	27.0	158	4,336,000	20	867,200
Total	....	2,907	73,148,000	....	14,635,600

approximately 1,900,000 acres, of which 400,000 lie without the district, at a cost per acre for main canals, $7.70, or a total cost, including pro rata of Lake Okeechobee-St. Lucie Canal, of $7.92.

RAINFALL IN THE EVERGLADES.

Plans for drainage of the Everglades will largely be determined according to the amount of rainfall that occurs over that region. Therefore, a close study of existing data is advisable. Within the Everglades no long-term precipitation records are available. Some stations have recently been established therein by this commis and by other official and private parties, but the terms of observ are not long enough to afford any useful data. Immediately after this commission began its work, rainfall stations were established at the following points: Detroit, Miami Canal, at Barkley's (about 8 miles above Miami), North New River Canal at Dredge Everglades (30 miles above Fort Lauderdale), Lake Okeechobee at head of North New River Canal, and Okeechobee Town on Taylors Creek, a few miles north of the lake. In addition to these interior stations, others have been maintained for short periods, viz: South New River Canal at Zona, North New River Canal at the lock (about 8 miles above Fort Lauderdale), Lake Okeechobee at Rita, Fla. (head of Miami Canal), and on Observation Island. During the maintenance of these stations, with the exception of the one last mentioned, no large general storms have been recorded. The records consist principally of local shower catchments. Therefore, they are almost valueless for the purposes of this report. The observations will, however, be hereinafter set down for purposes of record.

Records of rainfall at two or more points on or near the rim of the Everglades have been made since 1888. The location of these places are shown on the accompanying sketch map. During the past 14 years the Everglades have been well surrounded by observation stations. They may be classified as follows: Northern stations—Clermont, Kissimmee, and Orlando. Atlantic coast stations—Malabar, Fort Pierce, Jupiter, Hypoluxo, and Miami. Southern station—Flamingo. Western stations—Marco, Fort Myers, Arcadia, and Avon Park. Other stations on or near the Everglades rim, such as Bartow and Fort Meade have recently been established, but the term of record is too short to permit of valuable application here. Record of precipitation by months at the above-mentioned long-term stations is given in Table No. 1. (See pp. 19–22.)

Record of daily precipitation from May to September, inclusive, 1913, is set forth in Table No. 2. (See pp. 23–31.)

The figures set down in Table No. 1 represent the total and the average monthly and yearly precipitation at the several places of observation. In the plans originally adopted by the State for Everglades drainage, these average results largely formed the basis of conclusion as to the necessary capacity and number of drainage outlets. Therein lies in large part the cause of certain erroneous deductions that were then made.

It is clear that if a monthly rainfall of, say, 6 inches were distributed uniformly throughout one month, a comparatively small outlet capacity would suffice to carry all run-off water. If, on the other hand, the monthly rainfall of 6 inches occurred in one day, a serious flood would occur unless the outlet capacity were large. Therefore, in adjusting the proposed drainage canals in any swamp area, storm units rather than average monthly units must be used.

Study must also be given to the probable relative distribution of the storm precipitation. In order to have full information at hand and to conveniently study relative distribution, Table No. 3 has been prepared. It expresses the total catchment at the several points of observation of all the large storms that have occurred from 1899 to 1912, inclusive; also many of the smaller storms which were general [illegible] their extent. It has occasionally occurred that a general storm or [illegible] persisted over the entire month or has been so nearly continuous that it is impossible to separate the several storm units. In such cases the entire month's record has been entered in the table. (See Table No. 3, pp. 32–34.)

TABLE NO. 1.—*Rainfall at stations near the Everglades.*

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1888.													
Jupiter	1.50	3.27	1.25	4.08	8.86	5.52	3.72	4.44	8.72	3.78	3.98	3.26	53.38
Fort Myers	.10	4.25	1.10	2.00	5.35	11.36	5.95	8.34	11.82	5.46	4.56	2.60	62.89
Mean	.80	3.76	1.18	3.04	7.10	8.44	4.84	6.39	10.27	4.62	4.27	2.93	58.14
1889.													
Jupiter	9.84	4.16	2.00	2.33	3.45	9.80	4.00	7.85	6.15	3.05	2.47	.36	55.46
Fort Myers	5.31	1.87	2.38	1.75	1.49	11.81	7.69	11.78	10.51	.58	1.03	.16	56.36
Mean	7.58	3.02	2.19	4.04	2.47	10.80	5.85	9.82	8.33	1.82	1.75	.26	55.91
1890.													
Jupiter	2.41	2.00	2.44	1.13	13.51	2.51	6.92	8.70	8.69	5.43	4.95	2.66	61.35
Fort Myers	.24	.69	1.17	.39	8.17	7.23	6.47	8.51	10.19	3.21	2.15	.54	48.96
Mean	1.32	1.35	1.80	.76	10.84	4.87	6.70	8.61	9.44	4.32	3.55	1.60	55.16
1891.													
Jupiter	2.78	2.47	1.19	2.95	6.30	4.17	9.80	4.20	11.77	8.38	2.16	1.45	57.62
Fort Myers	2.85	.88	.50	3.41	1.19	6.26	8.34	9.90	......	4.44	2.00	.50	......
Mean	2.82	1.68	.85	3.18	3.75	5.22	9.07	7.05	11.77	6.41	2.08	.98	57.62
1892.													
Orlando	1.72	2.00	1.29	.60	2.67	4.37	1.63	9.05	9.12	4.66	.07	2.03	39.21
Jupiter	2.56	2.70	3.76	.53	2.30	14.76	.08	2.80	14.43	14.00	.89	4.44	63.25
Fort Myers	.40	.75	2.30	4.44	5.32	12.23	7.57	6.62	13.66	4.64	1.45	1.73	61.11
Mean	1.56	1.82	2.45	1.86	3.43	10.45	3.09	6.16	12.40	7.77	.80	2.73	54.52
1893.													
Clermont	1.47	4.87	4.79	.68	4.91	8.74	8.68	5.23	4.78	1.72	2.48	5.53	53.88
Kissimmee	1.66	3.67	1.89	1.70	4.51	12.47	5.49	5.87	4.65	6.42	2.29	1.56	52.18
Orlando	2.09	1.51	2.15	1.51	5.31	8.90	3.74	6.34	5.77	9.02	2.67	1.89	50.90
Jupiter	2.58	3.06	4.90	3.55	3.18	8.40	3.95	7.38	5.30	11.72	5.01	1.85	60.88
Fort Myers	2.42	.74	1.66	3.32	5.63	10.11	5.17	6.63	6.70	1.64	2.03	1.69	47.74
Mean	2.04	2.77	3.08	2.15	4.71	9.72	5.41	6.29	5.44	6.10	2.90	2.50	53.12
1894.													
Clermont	1.92	1.82	.59	.29	1.37	5.90	7.68	10.64	19.78	3.96	1.67	1.22	56.84
Kissimmee	2.29	1.40	.74	1.37	3.75	5.91	5.15	8.76	16.20	4.51	.82	2.54	53.44
Orlando	1.86	.98	.88	1.14	3.39	7.86	7.02	7.61	14.95	4.70	3.22	.56	54.17
Jupiter	2.55	.21	.69	.74	2.95	4.22	3.60	1.54	13.65	6.29	2.99	.99	40.42
Fort Myers	.68	1.55	1.07	1.30	1.47	15.55	5.15	8.79	9.89	4.58	.79	.24	51.15
Mean	1.86	1.19	.79	.97	2.59	7.89	5.72	7.47	14.89	4.81	1.90	1.11	51.20
1895.													
Clermont	4.07	3.06	1.28	5.14	3.73	3.23	7.73	5.36	2.40	2.97	1.53	1.34	41.84
Kissimmee	.70	3.34	1.40	7.82	3.86	1.20	7.30	5.53	7.50	5.40	5.10	.48	49.63
Orlando	1.29	3.11	1.70	5.15	7.31	3.21	4.36	4.78	4.27	3.78	1.57	1.78	42.31
Jupiter	3.33	2.75	1.59	4.02	6.10	3.85	5.88	3.86	8.99	21.03	4.80	6.27	72.47
Fort Myers	2.06	5.82	1.41	4.52	3.96	3.68	6.46	9.60	7.79	2.23	.79	1.76	50.08
Mean	2.29	3.62	1.48	5.33	4.99	3.03	6.35	5.83	6.19	7.08	2.76	2.33	51.26
1896.													
Clermont	4.77	3.95	1.37	.10	2.12	7.36	6.17	4.29	3.90	1.05	1.81	1.07	37.96
Kissimmee	4.79	7.31	.98	.24	1.51	12.57	9.24	4.17	6.82	3.78	3.23	2.36	57.00
Orlando	5.03	2.95	1.39	.00	2.71	11.18	10.66	5.24	3.88	1.07	3.53	1.95	49.59
Jupiter	5.06	2.64	2.35	1.59	2.83	8.92	8.27	4.32	5.65	5.98	2.40	3.25	53.26
Fort Myers	2.53	2.24	2.17	.32	9.02	20.90	9.04	2.90	11.12	4.72	1.26	3.43	69.65
Mean	4.44	3.82	1.65	.45	3.64	12.19	8.68	4.18	6.27	3.32	2.45	2.41	53.49
1897.													
Clermont	1.52	5.44	.45	2.01	.85	4.05	7.82	7.44	8.48	5.40	1.18	2.52	47.16
Kissimmee	.18	6.82	.28	2.75	4.26	5.44	5.70	4.63	15.20	3.00	.50	2.94	51.70
Orlando	1.16	3.99	.38	2.83	1.25	6.53	9.26	4.32	15.77	3.55	1.91	2.62	53.57
Jupiter	5.20	5.14	3.65	8.47	10.73	4.67	5.89	6.85	18.09	9.93	6.49	1.96	87.07
Miami	4.70	1.90	.75	10.55	7.20	5.30	......	2.20	20.35	7.35	1.15	1.00	......
Fort Myers	2.26	3.48	1.09	7.26	2.50	5.80	14.82	5.65	10.45	2.07	.73	1.06	57.17
Mean	2.50	4.46	1.10	5.65	4.47	5.30	8.70	5.18	14.72	5.22	1.99	2.02	59.33

TABLE No. 1—*Rainfall at stations near the Everglades*—Continued.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1898.													
Clermont	0.30	0.81	0.99	0.49	1.29	2.53	7.44	13.48	2.01	5.27	1.30	3.75	39.66
Kissimmee	.23	1.12	.00	.12	.35	5.75	7.90	11.41	4.52	5.17	.88	3.02	40.47
Orlando	.64	1.26	.54	.15	1.19	1.13	7.31	10.93	3.43	5.55	1.09	3.68	36.90
Jupiter	.36	.95	3.26	1.90	1.15	.12	6.80	6.62	3.38	10.89	1.11	2.56	39.10
Miami	.00	2.45	2.60	.60	1.65	.70	5.92	9.35	4.07	14.65	.40	1.50	43.89
Fort Myers	.05	.02	.46	.37	3.53	2.83	8.16	11.62	10.73	4.99	1.29	3.12	47.17
Mean	.26	1.10	1.31	.61	1.53	2.18	7.26	10.58	4.69	7.75	1.01	2.94	41.20
1899.													
Clermont	5.27	7.65	.85	2.66	2.29	5.59	6.63	11.73	6.23	5.75	.40	1.35	56.40
Kissimmee	5.72	11.53	1.68	3.06	1.60	3.06	8.37	11.06	7.03	15.98	.23	1.60	70.92
Orlando	5.04	8.71	.96	3.61	.96	4.15	7.01	6.28	7.77	9.22	.12	.93	54.76
Jupiter	4.30	4.64	3.58	3.11	1.65	3.45	3.35	5.96	11.27	16.66	.99	2.97	61.93
Miami	3.30	2.77	1.65	10.75	1.40	......	......	......	9.66	10.20	1.75	2.45	......
Fort Myers	5.21	8.77	1.23	1.74	1.15	5.93	12.08	6.72	2.31	2.58	.94	.58	49.24
Mean	4.81	7.33	1.66	4.16	1.51	4.44	7.49	8.35	7.38	10.06	.74	1.65	58.65
1900.													
Clermont	2.33	3.60	2.40	2.25	4.60	10.62	7.45	4.63	3.13	4.63	.10	5.15	50.89
Kissimmee	4.82	2.65	6.07	3.02	5.84	8.18	5.66	3.23	4.50	4.83	1.62	5.09	55.51
Orlando	3.32	2.45	6.93	3.39	4.72	7.62	10.83	7.41	5.53	6.78	1.51	3.36	63.85
Jupiter	3.49	2.28	8.20	2.16	7.43	2.90	3.49	1.12	7.62	10.13	.73	3.10	52.65
Hypoluxo	4.29	7.83	2.79	1.18	7.05	3.47	2.17	1.03	9.67	14.20	2.79	1.73	58.20
Miami	5.25	1.85	5.20	6.45	......	......	......	......	......	......	......	......	......
Fort Myers	3.17	3.99	4.12	2.87	4.65	7.12	9.63	9.77	8.29	10.33	1.91	2.78	68.63
Arcadia	2.70	3.80	8.05	3.58	1.89	5.08	9.23	6.27	4.80	.16	1.14	1.26	47.96
Mean	3.69	3.56	5.47	3.11	5.17	6.43	6.92	4.78	6.22	7.29	1.40	3.21	56.81
1901.													
Clermont	1.03	2.44	3.20	2.20	5.87	7.51	4.52	7.78	11.20	.40	.50	.73	47.38
Kissimmee	.92	2.26	3.51	3.23	2.96	8.78	2.84	9.91	12.95	1.18	.67	1.35	50.56
Orlando	1.07	3.27	3.89	2.47	2.15	11.81	4.28	13.18	11.12	2.20	.54	1.28	57.26
Fort Pierce	......	1.79	3.81	1.33	6.92	11.64	3.04	9.43	6.84	2.18	.66	3.91	......
Jupiter	8.29	1.07	2.30	2.13	3.63	17.41	7.22	12.13	9.71	7.08	.94	4.17	76.08
Hypoluxo	9.62	1.25	3.62	2.43	7.11	21.28	4.90	10.07	10.66	7.00	.79	3.94	82.67
Miami	......	T.	1.76	1.97	10.42	21.72	8.18	10.85	15.30	4.92	......	1.55	......
Flamingo	......	......	......	2.68	3.15	19.75	7.51	12.65	11.52	2.74	T.	2.60	......
Marco	.25	1.06	2.20	1.50	1.88	17.27	9.21	9.34	8.36	.10	.39	1.82	53.38
Fort Myers	.50	.72	2.67	1.89	2.30	20.28	5.23	12.41	6.86	.78	.52	1.62	55.78
Mean	2.84	1.71	3.03	2.21	4.39	15.30	6.16	10.93	9.88	2.62	.52	2.42	59.50
1902.													
Clermont	1.42	7.29	3.69	1.67	1.00	2.50	4.64	6.47	8.79	3.78	1.38	1.45	44.08
Kissimmee	.19	6.07	1.88	1.73	.34	5.85	5.36	7.27	6.35	3.07	1.15	.96	40.22
Orlando	1.25	4.50	1.81	2.27	1.52	6.94	5.43	3.53	13.66	4.90	.52	1.35	47.68
Fort Pierce	2.99	3.72	2.95	2.00	.62	5.92	6.74	5.11	9.47	11.37	2.42	2.26	55.57
Jupiter	.98	4.64	.97	.97	4.83	3.92	4.73	1.91	6.01	13.74	2.38	.71	45.79
Hypoluxo	2.10	5.54	1.62	1.81	3.98	7.88	1.72	4.96	7.98	18.99	3.58	1.00	61.15
Miami	.00	5.91	.00	1.85	.94	6.01	3.28	5.33	7.81	4.17	7.12	1.86	44.28
Flamingo	T.	.90	.00	2.45	3.05	4.15	2.94	7.10	3.55	5.30	2.55	1.13	33.12
Marco	.21	3.43	.61	1.21	4.79	8.61	8.41	3.44	4.10	4.80	1.86	3.05	44.52
Fort Myers	.52	6.79	.18	1.03	1.23	8.63	4.60	3.97	6.60	7.46	.96	2.93	44.90
Arcadia	.22	5.66	1.46	.29	.57	9.12	5.19	2.87	6.32	5.72	2.44	2.26	42.12
Avon Park	.27	5.49	3.29	1.44	3.71	5.70	8.68	4.43	9.03	7.77	1.77	2.44	54.02
Mean	.85	4.91	1.53	1.56	2.22	6.27	5.14	4.70	7.47	7.59	2.34	1.78	46.48
1903.													
Clermont	5.79	5.55	4.83	.02	2.47	8.15	8.04	6.48	6.39	.95	2.05	.83	51.91
Kissimmee	4.76	5.04	5.85	.25	6.68	10.12	6.07	4.31	12.06	1.02	3.56	1.51	61.22
Orlando	5.69	5.48	8.37	.51	3.59	11.05	8.41	3.68	8.08	1.69	2.71	1.00	60.26
Malabar	4.34	5.09	6.10	.09	4.12	1.64	1.49	4.84	8.14	.95	3.38	1.12	41.30
Fort Pierce	4.78	10.19	7.53	.00	1.77	4.93	4.60	5.82	12.93	.00	8.36	.60	61.51
Jupiter	6.94	4.50	9.27	.44	2.71	7.01	3.23	2.47	15.82	1.81	2.50	.56	57.26
Hypoluxo	5.70	4.70	6.69	.83	1.66	9.01	5.94	3.94	......	2.78	2.76	.98	......
Miami	4.99	4.70	3.82	......	1.35	10.48	......	......	12.54	4.48	3.70	T.	......
Flamingo	3.45	1.35	4.20	1.12	1.12	7.98	......	......	......	2.40	T.	.09	......
Marco	5.11	6.14	7.80	1.08	1.03	5.57	8.72	6.71	9.05	1.74	T.	.72	53.67
Fort Myers	4.76	3.37	7.78	T.	.17	10.45	11.40	5.50	4.15	1.62	2.02	1.61	53.37
Arcadia	4.65	5.54	5.24	.12	1.55	5.46	10.28	9.65	12.67	.34	2.83	2.14	60.47
Avon Park	5.22	5.40	5.85	.16	1.98	5.63	6.61	4.85	8.84	1.42	4.69	1.40	52.05
Mean	5.15	5.15	6.41	.39	2.32	7.50	6.79	5.30	10.06	1.63	2.88	.88	55.30

TABLE No. 1—*Rainfall at stations near the Everglades*—Continued.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904.													
Clermont	5.73	2.97	2.13	0.97	1.24	12.73	3.30	7.61	5.00	5.01	2.27	1.23	50.19
Kissimmee	4.16	5.16	.80	2.25	.51	8.19	8.56	4.53	4.66	6.72	3.15	.80	49.49
Orlando	4.02	2.45	1.09	2.20	2.16	9.11	6.40	6.33	5.00	8.44	1.80	1.06	50.06
Malabar	4.85	3.77	.46	.82	1.51	7.07	3.08	2.53	6.63	7.28	2.54	1.45	41.99
Fort Pierce	2.74	1.81	3.27	1.92	3.24	7.39	3.27	2.98	6.42	9.75	5.40	.08	48.27
Jupiter	2.56	2.10	3.06	2.85	2.42	10.54	4.38	5.79	8.92	21.39	3.68	.49	68.18
Hypoluxo	5.70	4.70	6.69	.83	1.66	9.01	5.94	3.94	......	2.78	2.26	.98	......
Miami	4.99	4.70	3.82	......	1.35	10.48	......	......	12.54	4.48	3.70	T.	......
Flamingo	1.36	T.	T.	1.08	6.47	5.25	......	......	......	7.41	5.66	1.00	......
Marco	3.00	.22	2.36	.36	1.39	8.14	5.34	4.75	5.44	2.96	2.51	.46	36.93
Fort Myers	3.12	2.00	1.90	1.10	3.57	14.87	5.60	6.30	3.07	1.78	1.93	.83	46.06
Arcadia	4.65	5.54	5.24	.12	1.55	5.46	10.28	9.65	12.67	.34	2.83	2.14	60.47
Avon Park	4.09	2.73	.96	2.42	3.82	10.35	7.56	5.96	5.39	11.25	2.90	1.46	58.89
Mean	3.92	2.93	2.44	1.41	2.37	8.35	5.79	5.49	6.88	6.89	3.16	.92	51.05
1905.													
Clermont	.27	2.40	2.84	2.10	2.88	5.86	5.03	10.91	15.61	.88	.03	6.64	55.45
Kissimmee	.70	.91	3.88	1.82	7.17	4.46	14.05	13.90	5.04	3.19	T.	9.43	64.55
Orlando	.41	2.12	5.13	1.71	8.12	8.13	6.15	17.13	13.11	3.42	.33	8.43	74.19
Malabar	1.04	.82	4.33	3.95	3.21	2.51	8.36	9.88	17.73	7.93	.39	6.05	66.20
Fort Pierce	.60	T.	2.43	4.95	3.25	2.62	5.51	3.71	5.61	5.72	1.46	3.41	39.27
Jupiter	1.40	1.50	5.39	3.14	3.35	2.09	9.12	10.72	10.77	4.26	2.88	15.18	69.80
Hypoluxo	2.29	1.75	2.80	4.06	2.51	2.72	10.46	6.16	8.02	5.45	2.47	7.00	55.69
Miami	2.65	.64	1.69	1.32	3.93	7.61	3.63	13.71	11.99	......	3.65	12.08	......
Flamingo	T.	.09	1.12	1.08	5.11	1.29	......	......	......	1.13	T.	10.10	......
Marco	.63	.00	.30	9.86	5.55	4.49	5.20	15.11	10.48	.93	.00	4.46	57.01
Fort Myers	.50	.10	.18	4.83	3.97	5.97	13.90	10.52	9.09	1.51	.06	6.21	56.84
Arcadia	.22	1.09	5.47	3.60	4.92	3.98	16.39	10.04	4.25	1.49	.69	6.85	58.99
Avon Park	.60	.61	3.51	3.01	6.99	4.48	13.70	12.72	5.66	3.86	.19	10.28	65.61
Mean	.87	.93	3.07	3.49	4.65	4.32	9.30	11.21	9.77	3.30	.94	8.23	60.32
1906.													
Clermont	5.57	.85	2.62	.50	11.23	9.89	7.61	4.43	2.19	.86	.25	.18	46.18
Kissimmee	6.43	1.49	2.74	1.48	6.77	10.21	6.65	2.59	3.26	2.00	.16	.04	43.82
Orlando	.41	2.12	5.13	1.71	8.12	8.13	6.15	17.13	13.11	3.42	.33	8.43	74.19
Malabar	2.32	3.18	2.52	.73	8.38	3.95	7.70	4.04	6.92	3.55	1.06	.26	44.61
Fort Pierce	3.07	2.85	2.55	2.07	8.26	12.05	6.04	6.70	2.61	7.34	4.27	.21	58.02
Jupiter	2.62	6.44	2.50	2.57	7.04	11.90	7.97	8.55	8.37	8.31	4.53	.05	70.85
Hypoluxo	3.98	4.67	3.70	4.19	8.42	12.30	7.31	7.47	5.44	9.76	4.40	.16	71.80
Miami	3.20	3.78	4.38	2.33	7.89	8.60	9.26	8.94	2.39	13.68	7.65	.00	72.01
Fort Myers	2.02	2.18	2.84	.21	6.12	11.00	9.69	12.02	3.39	2.41	.32	.02	52.22
Arcadia	3.58	2.60	3.03	.89	1.86	......	......	......	......	......	......	......	......
Avon Park	4.54	3.14	1.96	.98	4.44	9.36	7.91	9.56	1.28	.94	.05	.18	44.34
Mean	3.42	3.03	3.02	1.60	7.15	9.74	7.63	8.14	4.90	5.23	2.30	.95	57.80
1907.													
Clermont	.05	.62	T.	1.68	5.57	8.40	12.27	5.81	6.59	.95	.53	7.28	49.75
Kissimmee	6.43	1.49	2.74	1.48	6.77	10.21	6.65	2.59	3.26	2.00	.16	.04	43.82
Orlando	.02	.10	.15	2.20	2.75	8.17	9.96	9.20	5.15	1.91	.29	4.15	44.05
Malabar	.65	.32	.32	3.43	4.91	7.18	7.51	2.52	2.94	3.39	1.67	2.21	37.05
Fort Pierce	.40	.22	.68	1.19	4.77	......	4.47	2.89	......	......	2.87	5.54	......
Jupiter	.81	.08	.19	.69	4.58	9.00	4.34	3.10	7.47	5.65	2.10	1.82	39.83
Hypoluxo	1.39	2.60	.00	.50	3.58	10.80	5.52	4.06	3.80	5.18	.35	1.31	39.09
Miami	3.20	3.78	4.38	2.33	7.89	8.60	9.26	8.94	2.39	13.68	7.56	.00	72.01
Flamingo	......	.00	.00	.22	1.34	5.61	5.07	5.06	4.86	2.43	1.13	1.38	......
Fort Myers	1.30	.68	.08	.57	6.46	6.76	6.70	7.86	4.97	.55	.94	2.12	38.99
Arcadia	......	......	......	......	......	8.17	7.02	9.31	7.57	1.45	2.14	2.16	......
Avon Park	.36	.30	.24	1.27	7.72	9.43	8.50	7.08	4.59	3.83	.97	2.91	47.20
Mean	1.46	.93	.80	1.41	5.12	8.39	7.27	5.72	4.87	3.73	1.72	2.57	45.75
1908.													
Clermont	.05	.62	T.	1.68	5.57	8.40	12.27	5.81	6.59	.95	.53	7.28	49.75
Kissimmee	3.81	1.46	.26	6.13	3.08	4.32	4.74	9.40	8.48	2.18	2.36	.64	46.86
Orlando	3.57	1.56	.25	3.74	5.60	4.84	7.03	7.04	9.94	3.18	2.31	.68	49.64
Malabar	2.21	.70	.06	4.00	5.46	7.85	3.43	8.57	19.96	4.24	4.85	1.44	62.77
Jupiter	4.04	1.96	.67	.99	3.05	9.75	4.27	9.20	5.72	20.43	8.96	1.38	70.42
Fort Pierce	1.10	1.28	.33	2.92	2.44	5.93	9.10	7.51	15.44	10.05	6.45	.45	63.00
Hypoluxo	6.25	.79	.59	2.19	2.86	7.06	8.09	5.33	5.17	19.67	10.38	1.68	70.07
Flamingo	1.67	1.81	.71	5.73	1.26	10.92	5.71	12.67	5.01	......	......	......	......
Fort Myers	1.66	.94	.55	1.31	4.25	7.41	6.43	9.14	12.91	3.14	.33	.46	48.53
Arcadia	1.94	1.48	1.79	1.02	2.48	8.03	5.26	18.24	15.67	5.87	1.29	.55	63.62
Avon Park	3.14	.92	.02	1.73	3.01	5.98	4.92	7.32	10.30	1.62	2.48	1.02	42.41
Mean	2.68	1.23	.48	2.95	3.54	7.32	6.47	9.00	10.52	7.13	3.99	1.56	56.71

TABLE No. 1—*Rainfall at stations near the Everglades*—Continued.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1909.													
Clermont	1.60	3.58	0.45	2.53	3.94	12.11	17.01	8.89	2.33	0.20	1.05	0.84	54.53
Kissimmee	.86	.63	2.06	3.46	6.87	4.84	11.28	9.53	2.93	1.22	1.49	1.43	46.60
Orlando	1.31	1.14	1.40	2.17	2.41	3.13	12.71	8.34	3.41	1.30	.65	.67	38.64
Malabar	2.35	.43	3.70	2.88	5.66	2.88	7.34	6.04	3.92	2.41	1.28	1.38	40.27
Fort Pierce	4.63	.17	2.60	3.60	5.93	5.77	9.49	6.25	7.39	2.25	2.93	2.20	53.21
Jupiter	5.98	.41	2.69	4.97	8.61	4.35	6.61	4.53	7.59	5.57	.98	.99	53.28
Hypoluxo	4.38	1.22	2.30	9.11	5.28	3.79	9.31	7.01	18.16	10.63	.32	1.22	72.74
Miami	5.45	T.	.83	8.29	7.97	3.61	4.38	9.44	13.93	21.08	.60	1.20	76.78
Fort Myers	1.13	.52	.17	4.48	4.35	10.12	5.76	14.59	5.07	3.88	.38	1.10	51.55
Arcadia	1.06	.73	1.53	2.76	7.58	7.90	9.34	11.75	2.05	1.96	.13	1.85	48.64
Avon Park	.37	2.05	2.03	2.84	6.45	13.24	12.95	13.91	2.42	.79	.96	1.58	59.59
Mean	2.65	.99	1.79	4.18	5.91	6.52	9.66	9.12	6.15	4.66	.97	1.31	54.16
1910.													
Clermont	.80	3.76	......	.44	6.45	6.89	10.80	11.95	1.56	13.56	2.28	1.05	60.10
Kissimmee	1.29	2.47	1.52	.36	2.39	9.53	10.52	7.38	.74	11.65	.63	.65	49.13
Orlando	1.01	2.69	2.65	.38	2.87	15.25	9.71	6.36	2.82	11.73	2.80	80	59.07
Malabar	1.10	2.38	1.78	.28	1.76	7.64	5.05	16.16	2.94	12.62	.74	.33	52.78
Fort Pierce	.57	1.18	1.28	.28	4.15	4.60	9.27	12.60	3.02	12.79	1.08	.20	50.37
Jupiter	1.47	2.33	6.45	.51	4.26	7.53	4.99	10.46	4.92	20.88	1.31	1.11	66.22
Hypoluxo	1.43	5.05	3.62	1.91	5.27	7.08	5.30	3.61	3.26	27.81	......	......	......
Miami	1.46	.70	.67	1.16	3.06	6.78	5.12	6.90	3.67	21.45	.45	.55	51.97
Fort Myers	1.64	1.32	.73	.62	2.90	8.20	9.27	10.73	6.89	13.26	.89	.34	56.79
Arcadia	.97	1.45	.80	.24	7.88	7.65	7.79	7.26	6.21	13.16	.58	.64	53.63
Avon Park	.70	1.98	2.40	.61	5.48	14.37	9.04	8.32	2.26	12.49	.31	.62	58.58
Mean	1.13	2.31	2.19	.62	4.22	8.68	7.89	8.35	3.48	15.56	1.11	.63	55.86
1911.													
Clermont	.70	.00	1.43	.35	2.68	6.24	7.90	7.43	3.11	3.50	4.63	3.96	41.83
Kissimmee	1.04	.00	3.75	1.78	1.86	5.28	4.23	8.22	3.19	3.78	5.79	2.33	41.25
Orlando	.64	.06	1.29	2.36	3.07	4.94	6.27	5.66	3.71	4.23	4.73	2.65	39.61
Malabar	.71	.06	1.51	3.65	6.33	3.88	4.97	8.00	1.40	4.86	5.49	4.94	45.80
Fort Pierce	......	......	......	......	......	......	2.75	3.40	1.80	8.00	2.00	5.40	......
Jupiter	.37	.09	2.32	......	......	......	......	......	......	......	......	......	......
Hypoluxo	......	.00	.72	2.81	10.30	2.77	3.32	5.12	5.77	7.26	......	1.34	......
Miami	1.82	T.	1.10	10.11	12.12	2.83	4.08	6.27	4.42	3.53	5.94	1.90	54.12
Fort Myers	.46	T.	.68	3.06	8.49	8.77	4.05	11.19	5.87	4.62	1.53	.37	49.09
Arcadia	.23	.10	1.45	1.43	4.55	4.79	5.20	7.17	2.44	5.57	1.44	1.47	35.84
Mean	.73	.03	1.58	3.19	6.17	4.94	4.75	6.94	3.52	5.04	3.94	2.71	43.93
1912.													
Clermont	7.82	1.16	4.00	2.19	8.25	15.42	5.68	3.85	7.60	4.58	2.50	......	......
Kissimmee	7.87	2.29	3.75	1.31	7.48	11.90	4.74	4.10	7.59	4.38	3.01	.66	59.08
Orlando	8.54	1.92	2.11	4.30	6.60	12.17	7.48	7.72	9.63	4.97	1.80	1.21	68.45
Malabar	4.52	2.54	1.37	1.94	2.24	10.20	6.09	2.50	5.56	6.98	2.82	1.49	48.25
Fort Pierce	2.80	1.40	1.80	3.40	6.30	10.20	.75	5.42	3.95	6.10	1.60	1.90	45.62
Hypoluxo	5.14	3.03	1.51	2.22	14.40	25.19	3.26	1.19	4.36	5.70	2.13	8.43	76.56
Miami	4.26	2.08	3.76	5.61	11.17	14.63	5.99	2.93	2.08	3.29	10.67	1.90	68.37
Fort Myers	1.93	2.93	4.35	.20	......	......	8.42	9.06	5.43	5.43	1.32	1.03	......
Arcadia	4.53	2.21	3.44	.84	7.84	16.49	3.31	5.57	6.97	5.17	1.13	1.15	58.63
Avon Park	5.24	1.97	......	......	......	16.91	2.90	4.98	7.93	3.29	1.27	.74	......
Mean	5.26	2.25	2.90	2.45	7.13	14.80	4.86	4.73	6.11	4.99	2.82	2.06	60.38
Grand mean	2.68	2.76	2.17	2.40	4.46	7.73	6.72	6.81	8.06	5.80	2.17	2.11	54.34

TABLE No. 2.—*Daily rainfall for January, 1913.*

Date.	Rita.	Arcadia.	Avon. Park.	Cler-mont.	Bartow.	Fort Meade.	Orlando.	Kissim-mee.	Malabar.	Fort Pierce.	Hypo-luxo.	Miami.
1	0.00	0.00	0.03	0.12	0.09	0.00	0.36	0.00	0.00	0.00	0.00	0.00
2	.00	.16	.02	1.00	.09	.00	.05	.00	.03	.00	.00	T.
3	.00	.37	.66	.00	.55	.00	.21	.27	.55	.40	.50	.54
4	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	T.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	T.	.00	.07	.00	.00	.05
7	.00	.00	.00	.00	.00	.00	T.	T.	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.07	.00
9	.00	.04	.00	.00	.00	.00	.00	.14	.00	.00	.00	.00
10	.00	.00	T.	.00	.00	.00	T.	.00	.05	.10	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.02	.00	.02	.00
13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	.40	.00	.00	.00	.00	.00	.00	.00	.26	1.30	.02	.00
15	.20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.28	1.22
16	.00	.00	.00	.00	.00	.00	T.	.00	.02	.00	.03	.06
17	.00	.00	.00	.00	.00	.00	T.	.00	.00	.00	.00	.12
18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.76
19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.34	.17
20	.00	.00	.00	.00	.00	.00	.00	.00	.13	.00	.12	.00
21	.00	.00	.00	.00	.00	.00	.00	.00	.01	.00	.10	.09
22	.00	.00	.35	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
24	.00	.00	.00	.00	.00	.00	T.	.00	.00	.00	.00	.00
25	.00	.00	.00	.25	.00	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
27	.50	.61	.29	.00	.00	1.36	.20	.13	.11	.70	.14	.29
28	.00	.00	.00	.00	.60	.00	.00	.00	.00	.00	.05	.09
29	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
31	.00	.16	.37	.10	.00	T.	.10	.00	.01	.00	1.56	.03
	1.10	1.34	1.72	1.47	1.33	1.36	.92	.54	1.26	2.50	3.23	4.42

TABLE NO. 2.—*Daily rainfall for February, 1913*—Continued.

Date.	Zona.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.00	0.02	0.00	0.00	0.04	0.00	0.05	0.00	0.04	0.00	0.04	0.02
2	.00	.00	.27	.00	.00	.00	T.	T.	.03	.00	.00	.06
3	.18	.00	.00	T.	.06	.00	.00	.00	.00	.00	.07	.04
4	.00	.00	.00	.00	.00	.00	.05	.08	.07	.00	.00	T.
5	.00	.02	.04	.00	.00	.00	.00	.55	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	T.	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.07	.00	.04	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.01	.02	.00	.00	T.	.49	.20	.07	.00	.00	.00
13	.00	.43	.55	2.30	.31	1.77	.41	.58	.45	.60	.00	.00
14	.00	1.30	1.33	.60	2.13	.86	1.76	1.79	1.63	.70	.00	.00
15	.17	.53	.73	.45	.51	.48	.98	1.00	1.45	.90	1.53	.55
16	.00	.00	.00	.00	.28	.00	.00	.00	.00	.00	.00	.00
17	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
18	.00	.00	.00	.00	.00	.00	.00	.00	.03	.10	.00	.00
19	.00	.11	1.10	1.10	.00	1.05	.17	.40	.00	.50	.05	.62
20	.43	.71	.00	.00	1.14	.05	.53	.52	.00	.00	.87	.30
21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
22	.00	.00	T.	.32	.00	T.	.29	.14	1.80	.00	.00	.00
23	.00	.20	.33	.00	.40	.42	.07	.00	.05	.10	.00	.00
24	.36	.32	1.28	.15	1.08	.96	.30	.79	.15	.50	.70	.27
25	.00	.02	.00	.00	.38	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.30	.00
27	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	1.14	3.67	5.55	4.92	6.33	5.59	5.10	6.05	5.84	3.40	3.60	1.86

TABLE No. 2.—*Daily rainfall for March, 1913*—Continued.

Date.	Rita.	Zona.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.40	0.00	0.00	T.	0.70	0.00	0.00	T.	0.00	0.00	0.00	0.00	0.00
2	.00	.00	.40	0.55	.00	.86	.86	0.63	.70	.40	.40	.00	.75
3	.00	.00	.02	.00	.00	.02	.00	.00	.00	.00	.00	.00	.03
4	.00	.00	.00	.14	.93	.00	.17	.05	T.	.00	.00	.00	.00
5	.00	.00	.35	.32	.00	.48	.00	.15	.19	.58	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.10	.00	.00
10	.00	.00	.00	.97	.00	.00	T.	T.	T.	.10	.00	.00	.00
11	.00	.31	.00	.12	.00	.08	.00	.90	1.55	.00	.00	.00	.10
12	.04	.00	.00	.00	.00	1.04	.00	.00	.98	.00	.00	.00	.00
13	.01	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.20	.00	.52	.00	.00	.00	.00	.00	.05
16	.00	.14	.18	.35	1.10	.03	.00	.15	.25	.10	.30	.49	.11
17	.02	.30	.02	.04	1.30	.00	T.	.21	.17	.11	.00	.33	.46
18	.50	.70	.65	.59	.15	.84	1.43	1.15	1.08	.70	1.10	.79	1.84
19	.20	.39	.18	.39	.10	.80	1.27	.95	.80	.99	1.20	.30	.16
20	.01	1.95	.03	.35	.30	.60	.24	.12	.35	1.12	.10	.03	.00
21	.50	.05	.90	.33	.00	.27	.46	.20	1.09	.05	.00	.03	.00
22	.00	.00	.09	.02	.00	.83	.00	.00	.00	.13	.60	.18	.02
23	.05	.35	.02	.00	.00	.00	.00	.12	T.	.00	.00	.20	T.
24	.08	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.07
25	.00	.00	.00	.00	.00	.04	.00	.05	.00	.00	.00	.05	.06
26	.00	.00	.16	.00	.00	.00	.00	.00	.00	.10	.00	.04	.00
27	.02	.08	.17	.03	.41	.13	.42	.73	.15	.00	.00	.08	.00
28	.00	.27	.00	.00	.00	.31	.00	.00	.00	.00	.40	.30	.34
29	.14	1.82	.06	T.	.00	.00	.00	.00	.00	.00	.40	.70	.36
30	.00	.00	.01	.00	.87	.00	.00	.16	.33	.46	.30	.00	.00
31	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00	.04
	1.97	6.32	3.26	4.22	6.06	6.35	5.37	5.57	7.64	4.84	4.90	3.68	4.39

TABLE NO. 2.—*Daily rainfall for April, 1913*—Continued.

Date.	Rita.	Zona.	L. N. Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.15	.00	1.50	.00	.00	.00	.00	.00	.00
5	.01	.47	1.23	1.99	.74	.00	1.50	.00	.00	.00	.00	.10	.44	.49
6	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.08	.00
7	.00	T.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.60	.00	.00
11	.00	.00	.23	.00	.00	1.53	.00	.00	T.	.15	.52	.60	.00	.00
12	.77	3.55	2.31	.44	1.09	1.00	2.11	1.04	.45	.65	.45	.80	.17	1.89
13	.11	.30	.06	.02	.03	.00	.11	.00	.82	.00	.00	.90	.35	1.18
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.05	.00	.00	.00	.00	T.	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02
21	.23	.05	.00	T.	.00	T.	.00	T.	T.	.00	.32	.00	.38	.00
22	.00	.10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
24	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
25	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00	.00	.07	.00	.00	.00	.00	.00
27	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.30	.00	.00	T.	T.	.00	.00	.00	.00
29	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	T.	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.20
	1.25	4.47	3.83	2.50	1.86	2.98	3.72	2.54	1.34	.80	1.29	3.00	1.42	3.78

TABLE No. 2.—*Daily rainfall for May, 1913*—Continued.

Date.	Rita.	Everglades.	Zona.	Barkleys.	Detroit.	Lower North Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.00	....	0.00	....	....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
2	.00	....	.10	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.08
3	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.02	....	.00	....	....	.00	.37	.93	.00	.00	.66	.37	.35	.00	.00	.00	.00
9	.43	....	T.	....	....	.00	.00	.12	.00	.07	.60	.18	T.	.02	.00	.00	.00
10	.00	....	.00	....	....	.10	.00	.00	.00	.15	.00	.00	.00	.08	.21	.00	.00
11	.07	....	.00	....	....	.65	.11	.07	T.	.00	.93	T.	.00	.01	.07	.17	1.70
12	.08	....	1.55	....	....	1.45	.16	2.95	.78	.38	1.00	.20	1.45	.09	1.07	.89	.21
13	.60	....	.22	....	....	.08	.11	.05	.00	.63	.00	.00	.00	.22	.00	.76	.00
14	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	....	.00	....	....	.00	.00	.00	.00	.00	.00	.00	.00	.01	.25	.08	.00
17	.08	....	.00	....	....	.00	.00	.00	.00	.00	.00	.07	T.	.08	.06	.00	.00
18	.38	....	.00	....	....	.65	.00	.02	.00	.83	.00	.07	.00	.23	.43	.08	.00
19	.00	....	.00	....	....	.02	.00	.18	.00	.00	.00	.42	.12	.00	.03	.00	.00
20	.00	....	.07	....	....	.00	1.65	.00	T.	.16	.00	.00	.00	.00	.00	.00	.00
21	.00	....	.00	....	....	.00	.08	.00	.00	.33	.00	.00	.00	.00	.00	.00	.00
22	.00	....	T.	....	....	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	.02	....	T.	0.01	....	.42	.00	.39	.28	.00	.00	.10	.16	.03	.61	.07	.05
24	2.45	....	1.18	2.10	....	.82	1.20	.69	.27	.03	.94	.25	.25	.22	.45	1.65	3.69
25	.95	....	1.45	.30	....	2.20	.04	.92	.00	.25	T.	.42	.10	.06	.37	.81	2.69
26	.02	....	.12	.23	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.03	T.
27	.08	....	.11	.00	....	.14	.16	.07	.00	.00	.00	.00	.00	.00	.00	.11	.00
28	.17	....	T.	.00	0.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.03	.02	.00
29	.00	0.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
31	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	5.35	.00	4.80	2.54	.03	6.89	3.88	6.39	1.33	2.83	4.13	2.08	2.43	1.08	3.58	4.67	8.42

TABLE No. 2.—*Daily rainfall for June, 1913*—Continued.

Date.	Rita	Ferguson.	Okeechobee.	Everglade.	Zona.	Barkleys.	Detroit.	Lower North Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.00	0.00	....	0.00	0.00	0.00	....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	.53	.00	....	.00	.00	.00	....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.11	.00	....	.00	.05	.46	0.86	.00	.01	.00	.45	.00	.00	.00	.00	.00	.00	.38	.00
4	.00	.80	....	.00	.00	1.61	.66	.01	.19	.17	.00	.57	.00	T.	.00	.00	.00	.10	T.
5	.73	.00	....	1.11	.68	1.05	.48	.67	1.19	.13	.00	.00	.00	T.	.22	T.	.00	.12	.56
6	.24	.90	....	.07	T.	.00	T.	.05	.01	.72	.00	.07	.00	.10	.10	.02	25	.03	.00
7	.00	.00	....	.06	.05	.00	.02	.05	.00	.00	.00	.07	.00	.00	.00	.00	.08	.00	.00
8	.23	.53	....	1.05	.75	.25	.31	.58	.00	.00	.00	.00	.00	.00	.00	.00	.04	1.05	.46
9	.16	1.35	....	1.70	1.00	.27	T.	1.34	.00	.98	.38	.00	.00	.40	.50	.45	.64	.37	T.
10	.01	.00	....	.00	.00	.00	.00	.00	.57	1.49	.40	.04	1.00	.10	.39	.17	.31	.19	.02
11	.61	.00	0.00	.72	.06	.00	.00	.35	.23	.25	.00	1.89	.85	T.	.92	.35	.08	.09	T.
12	.00	.02	.02	.00	.63	.36	.02	.30	.01	.00	T.	.06	.00	.00	.00	.05	1.08	.00	.80
13	.00	.00	.00	.00	.10	.00	.70	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	T.
14	.00	.00	.00	.00	.00	.03	1.83	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.04
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
19	.00	.00	.00	.00	T.	1.00	T.	.17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.77
20	.00	.07	.00	.00	.08	1.95	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.86
21	.00	.00	.00	.00	.25	.24	.66	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	T.
22	.00	.00	.49	.00	T.	.10	.00	.00	.06	.38	T.	.00	2.15	.03	.00	.00	.00	.00	.16
23	.22	.11	.01	.00	.30	.47	.00	.00	.37	1.15	T.	.41	T.	T.	.00	.00	.00	.00	T.
24	.36	.66	.30	2.01	.27	.26	.08	.00	.00	.00	.00	.02	T.	.00	.00	.00	.00	.22	T.
25	.05	.02	.00	.25	.07	.02	.36	.00	.00	.00	.00	.11	.00	T.	T.	.01	.00	.00	.01
26	.16	.77	.04	.00	.12	.97	.59	.00	.05	.87	.00	.02	.80	.00	.19	.00	.00	.99	.00
27	.01	.00	.28	.00	.00	.00	.00	.00	.84	1.19	.00	.72	.00	T.	T.	.00	.00	.09	.00
28	.00	.00	2.60	.00	.00	.86	.00	.00	.45	.67	.00	.32	.65	1.25	.45	.30	.00	.00	.37
29	.11	.00	.03	.00	.20	.00	.19	.00	.04	.69	.57	2.15	.32	.47	.69	.50	.00	.00	.02
30	.17	.00	.09	.00	2.25	.00	.00	.00	.02	.03	.00	.10	.15	.00	.00	1.05	.19	.28	.00
Total	3.70	5.23	3.86	6.97	6.86	9.90	6.77	3.52	4.13	8.72	1.80	6.55	5.92	2.35	3.45	2.90	2.67	3.91	4.07

TABLE NO. 2.—*Daily rainfall for July, 1913*—Continued.

Date.	Rita.	Ferguson.	Okeechobee.	Everglade.	Zona.	Barkleys.	Detroit.	Lower North Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.03	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.07	0.05	2.41	0.00	0.00	0.00	0.00	T.
2	.00	.01	.51	.04	.00	.00	.00	.00	.36	.08	T.	.01	T.	.00	.00	.00	.00	.00	0.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.01	.16	T.	.27	T.	.00	.14	.00	.00	.00	.00
4	.00	.00	.43	.00	.00	.00	.00	.00	.11	.22	.00	.57	.30	.00	.16	.00	.00	.00	.00
5	.00	.00	.00	.00	.17	.70	.02	.00	.27	.00	.00	.00	.42	.00	T.	.00	.00	.00	.00
6	.00	.00	.00	.18	.17	1.65	1.56	.65	.17	.27	.62	.10	.10	1.56	.19	.06	.01	.00	.56
7	.07	.00	.31	.02	.17	.03	.00	.72	1.50	.00	.00	1.27	.00	.15	.21	.00	.00	.00	T.
8	.05	1.35	.00	.56	.24	1.27	2.43	.00	.04	.21	.10	.00	.00	.00	T.	.06	.00	.00	.40
9	.77	1.70	.00	.04	.86	.00	.24	.55	.00	1.26	2.00	.20	.87	T.	.13	.00	.45	2.20	.00
10	.13	.07	.17	.03	.00	.00	.00	.00	.02	.00	.00	1.51	.00	.34	.00	.00	.00	.11	.00
11	.00	.02	.00	.00	.00	.00	.00	.25	.42	.00	.00	.00	.30	T.	.00	.00	.00	.31	.44
12	.00	.02	.00	.56	.05	.36	.25	.00	.02	.00	.00	.22	.00	.00	.60	.02	.08	.00	.00
13	.00	.76	.00	.34	.00	.00	.00	.25	1.08	.00	.50	.00	.85	1.55	.10	.00	.00	.00	.00
14	.18	.00	1.37	.00	.03	.00	.79	.00	.06	.18	.00	.15	.40	.00	.00	.00	.00	.00	.27
15	.02	.00	.00	.00	.13	.76	1.09	.00	.38	.45	.45	.00	.00	.00	.00	.00	.00	.00	.07
16	.00	.00	.00	.21	.00	.00	.00	.00	.00	.00	T.	.07	.00	.10	.00	.00	.00	.00	.00
17	.00	.00	.46	.57	.00	.00	.13	.00	.15	.74	.00	.00	1.73	.00	.00	.00	.00	.00	.00
18	.00	.00	.23	.00	.00	.05	.10	.00	.08	1.81	.00	.03	T.	1.78	.98	.00	.00	.00	.30
19	.00	.00	.00	.01	.00	.94	.00	.00	.03	.00	.62	.09	.00	.00	.05	.00	.00	.26	.00
20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05	.00	.00	.00	.25	.00	.12	.04	.00	.03
21	.08	.07	.00	.23	.00	.00	.09	.00	.00	.00	.45	.01	.36	.03	.00	.00	.39	.50	.01
22	.02	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00	.00	1.95	.30	T.	.00	.00	.02	.00
23	.06	.03	.00	.00	.04	.00	.00	.00	.00	.33	.00	.75	.11	1.83	.65	.00	.00	.00	.25
24	.00	.00	.88	.00	.00	.63	T.	.00	.10	.00	.00	.00	.58	.00	.00	.00	.08	.00	.00
25	.08	.68	.00	.72	.00	.00	.00	T.	1.00	.00	.00	.00	.10	.00	T.	.00	.00	.00	T.
26	.10	.46	.00	.08	.04	.09	.01	.35	.03	.00	.00	.03	T.	.05	.00	.00	.00	.00	.00
27	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.12	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.00	.06	.05	.00	T.	T.	.00	.11	.00	.00	.00	.00	.00	.17
29	.00	.00	.00	.04	.07	.06	.00	.35	.02	.23	.00	.01	.01	.00	.00	.00	.04	.00	.48
30	.08	.00	.08	.20	.45	.13	.10	.00	.00	.76	.00	.05	.02	.16	.35	.00	.00	.00	.00
31	.40	.00	.00	.00	.00	.00	.00	.00	.00	.72	.00	.40	.00	.00	.00	.00	.00	.00	T.
	2.12	5.17	5.00	3.83	2.42	6.67	6.89	3.17	6.22	7.47	4.74	5.81	8.26	10.53	3.68	.26	1.09	3.50	2.98

TABLE No. 2.—*Daily rainfall for August, 1913*—Continued.

Date.	Rita.	Ferguson.	Okeechobee.	Everglade.	Zona.	Barkleys.	Detroit.	Lower North Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce	Hypoluxo.	Miami.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	T.	0.13	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
2	.00	.00	.00	.18	.24	.26	00	.35	.06	.00	.00	.00	.00	.35	.00	.52	.00	.00	.43
3	1.23	2.65	.00	.00	1.73	.00	.49	1.75	.30	.79	.47	.00	1.64	.80	T.	.00	.00	1.65	.00
4	.00	.07	.00	.00	.00	.04	.04	.00	1.22	.10	.00	.04	.83	.68	.25	.07	.26	.02	.00
5	.00	.00	.60	.06	.32	.13	.00	.12	.57	.11	.00	1.10	T.	.48	.48	.11	.24	.00	.00
6	.54	.03	.23	.33	.00	.15	.46	.25	.08	.00	.00	.70	.00	.06	1.97	.04	2.43	.00	1.61
7	.39	.22	.00	.38	.17	.07	1.25	.00	.16	.00	.20	.00	.87	.57	T.	.05	.22	1.55	.12
8	.00	.00	.18	.00	.00	.00	.00	.00	.01	.00	.00	1.23	.00	.00	.48	.00	.00	.00	T.
9	.00	.00	.00	.00	.00	.07	.00	.08	.06	.17	.00	.00	.00	.06	T.	.00	.00	.07	.00
10	.20	.52	.38	.00	.01	.02	.15	.05	1.22	.08	.00	.01	.02	.08	.00	.00	.13	.07	.05
11	.01	.07	.16	.41	.03	.00	.23	.00	.07	.00	.00	.20	T.	.65	.00	T.	.02	.10	.07
12	.00	.00	.00	.00	.00	.10	.00	.00	.02	.00	.00	.01	.00	.02	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.32	.00	.00	.27	.04	.00	T.	.00	.08	.35	.00	.00	.00	.00	.20	.06	.00	.07
15	.02	.00	.00	.08	.80	.00	.71	1.55	1.50	.63	.15	.00	.00	.55	.60	.00	.00	.58	.00
16	.15	....	.00	.03	.25	1.65	.18	.31	.51	.37	.00	.10	.00	.10	.00	T.	.00	.09	1.27
17	.01	.01	.65	1.28	.29	1.95	.00	.15	.06	.02	.00	.00	.00	.00	.00	.05	.00	.09	.14
18	.09	.22	.00	.00	.00	.00	.00	.76	.00	.00	.00	.00	.00	.00	.00	.00	.00	.86	.56
19	.90	1.05	.19	.13	.00	.25	.06	.00	.61	.00	.00	.00	.00	.00	.00	.00	.00	.25	.14
20	.26	.01	.00	.00	.00	.15	.00	.00	1.27	.11	.00	.00	.00	.45	.00	.00	.00	.08	.00
21	.87	1.23	1.58	.44	.00	.12	.33	.15	.15	.54	1.50	.78	.46	.08	.64	3.10	.53	.21	T.
22	1.24	.74	.66	2.77	....	1.96	1.60	.05	1.14	.07	.00	2.10	.48	.21	.45	.00	.00	1.22	.12
23	.05	.08	.00	.12	.17	.03	.50	.08	.10	.62	.20	.01	.00	T.	.00	.00	.60	.41	.06
24	1.15	.92	.16	.22	.04	.78	.00	.00	2.57	.03	.00	.27	.00	T.	.08	.06	.00	.00	.67
25	.11	.09	.00	.68	.00	.00	.00	.06	.20	1.36	.00	.15	1.80	T.	.00	.03	.20	.00	.01
26	.00	T.	.00	.00	.09	.00	.00	.00	.04	.06	.75	.55	.86	.00	.00	.00	.00	.00	.00
27	.03	.03	.00	.00	.00	.00	.00	.00	.24	.46	.83	.19	.26	.10	.12	.00	.00	.16	.02
28	.00	.00	.48	.00	.00	.00	.00	.00	.04	.05	.12	.17	.00	1.35	.49	.00	.00	.00	.00
29	.05	.57	.00	.00	.02	.00	.01	.00	.00	.00	.00	.00	.00	T.	.00	.08	.00	.17	.00
30	.36	.86	.00	.00	.13	.00	.02	.00	.00	.00	.76	.01	T.	T.	.08	.04	.00	.00	.26
31	.00	.00	.00	.00	.00	.00	.00	.00	.12	.68	.00	.49	T.	.00	.17	.00	.00	.00	.00
	7.66	9.69	5.27	7.11	4.86	7.77	6.04	5.71	13.07	6.34	5.46	8.12	7.22	6.59	6.16	4.35	4.69	7.39	5.60

TABLE NO. 2.—*Daily rainfall for September, 1913*—Continued.

Date.	Rita.	Ferguson.	Okeechobee.	Everglade.	Barkleys.	Detroit.	Lower North Canal.	Arcadia.	Avon Park.	Clermont.	Bartow.	Fort Meade.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.
1	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.92	0.00	0.00	T.	0.00	0.00	0.00	0.04
2	.00	.00	.03	.00	.00	.33	.00	.06	.00	.00	.00	.00	.00	0.00	.00	.00	.06	T.
3	.08	.00	.00	.00	.82	.02	.44	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.70	1.11	.00	.00	.18	.25	.54	.00	.00	.00	.00	.00	.55	.08	.00	.00	.23	.57
5	.12	.30	.00	.08	.31	1.08	1.38	.31	.19	1.00	.00	.26	.50	1.15	.00	.10	.20	.05
6	.04	.02	.12	.31	1.80	1.29	.03	.60	.02	.70	.20	T.	.15	1.48	.00	.90	.93	2.62
7	.15	.08	.00	.05	.15	.54	.16	.02	1.31	.60	.00	1.08	.05	T.	.00	.00	.15	.20
8	.23	.11	.24	.00	.24	.01	.02	.00	.43	.00	.77	.05	.00	T.	.00	.10	.08	.01
9	.00	.00	.00	.00	.05	.00	.10	.00	.00	.00	.00	T.	.15	.35	.00	.00	.00	T.
10	.00	.00	.08	.00	.00	.00	.36	.07	.02	.00	.00	T.	.00	.00	.56	.00	.00	.00
11	.28	T.	.00	.00	.00	.02	.00	.00	.27	.00	.00	.00	.05	.00	.13	.20	.14	.07
12	2.05	.49	.25	.26	.13	1.61	1.45	.00	.02	.00	.00	.23	.00	.00	.00	1.80	1.20	.67
13	.04	.21	.18	.58	.88	.35	.05	T.	.02	.00	.00	.00	.00	.00	.00	.01	.14	T.
14	.87	1.34	.00	.27	.05	.00	.00	T.	.00	.00	.00	.15	T.	.00	.00	.00	.00	T.
15	.00	.04	.41	.00	.35	.01	.00	.07	.00	.00	.10	.20	.00	.00	.00	.00	.00	.15
16	.03	T.	.46	.21	.91	.30	.53	.00	.00	.00	.14	.40	.00	.48	.28	1.10	.50	1.52
17	.00	.00	.00	.00	.02	.00	.00	.10	.03	.33	.33	T.	.00	.00	.00	.00	.00	.08
18	.16	.31	.00	.00	.00	.00	.00	.23	.00	.29	.02	.62	.00	.00	1.02	.00	.00	.00
19	.13	.50	.00	.22	.00	.00	.00	.00	.03	.00	.00	.36	3.47	1.40	.00	.19	.00	.00
20	.35	.00	.16	.52	.03	.00	.13	.12	.50	.94	.91	.00	.12	.81	.92	1.10	.00	.00
21	.02	.01	.00	.00	.31	.01	2.13	.14	.05	.34	.83	.23	.40	T.	.21	.06	.54	.09
22	.00	.00	.00	.00	.00	.00	1.28	.00	.00	.00	.03	.00	.10	.00	.00	.00	.02	.00
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
24	.00	.03	.28	.00	.42	.15	.50	.00	.38	.00	.00	.57	.07	.28	.36	.00	.15	.16
25	.10	.07	.09	.22	.12	.21	.20	.02	.00	.00	.18	.00	.00	.00	.00	.00	.73	.08
26	.01	.00	.00	.33	.00	.07	.33	.04	.84	.00	.00	.00	.00	.00	.00	.66	.21	.15
27	.10	.00	.00	.00	.00	.00	.00	1.35	.03	.00	.00	.47	.00	.00	.00	.00	.08	.00
28	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	T.
29	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Total	5.46	4.62	2.30	3.05	6.77	6.32	9.63	3.16	4.34	4.20	4.43	4.62	5.61	6.03	3.48	6.22	5.36	6.46

TABLE NO. 3.—*Storm precipitation.*

Date.	Clermont.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Jupiter.	Hypoluxo.	Miami.	Flamingo.	Marco.	Fort Myers.	Arcadia.	Avon Park.	Observation Island.
1899.														
Jan. 16–18	....	1.26	1.67	....	....	0.26	....	....	....	....	1.45	....	....	....
Jan. 23–24	....	1.16	1.46	....	....	.20	....	....	....	....	.77	....	....	....
Jan. 26–28	....	2.03	1.47	....	....	1.31	....	....	....	....	2.87	....	....	....
Feb. 12–13	1.44	1.23	.42	....	....	.79	....	....	....	....	1.01	....	....	....
Feb. 15–16	1.78	1.79	2.30	....	....	1.06	....	....	....	....	6.05	....	....	....
Oct. 1–5	5.50	6.98	13.72	....	....	13.42	....	....	....	....	1.82	....	....	....
1900.														
Sept. 1–8	2.38	5.29	4.15	....	....	6.86	7.50	....	....	....	5.37	....	....	....
Oct. 9–13	4.20	5.13	3.17	....	....	1.86	2.16	....	....	....	7.14	....	....	....
1901.														
Mar. 26–27	2.00	1.23	.73	....	1.34	.08	1.60	0.58	1.35	0.07	.92	....	....	....
May 20–23	2.40	.64	.46	....	3.35	2.03	3.49	5.39	2.00	.10	....	....	....	....
May 26–27	2.98	.85	2.30	....	1.94	.77	.82	.98	1.15	1.00	1.52	....	....	....
June 10–16	4.82	6.73	3.36	....	8.02	19.22	13.97	15.72	7.25	13.32	15.72	....	....	....
Sept. 25–30	10.85	7.11	4.46	....	3.52	2.70	5.92	12.80	....	4.16	2.48	....	....	....
1902.														
Feb. 20–21	2.85	2.15	2.65	2.95	2.45	....	3.04	3.55	....	1.80	5.09	....	....	....
June 13–14	1.24	5.11	3.30	6.00	5.16	2.65	2.01	2.94	2.10	5.47	4.13	....	....	....
Sept. (all)	8.79	13.66	6.35	8.48	9.47	6.01	7.98	7.81	3.55	4.10	6.60	....	9.03	....
1903.														
Jan. 20–21	.93	1.83	1.66	2.09	2.60	3.43	3.62	2.50	2.00	2.40	1.63	....	2.08	....
Feb. 21–23	3.85	1.52	3.71	3.51	8.23	3.67	4.34	4.20	1.35	5.65	2.87	....	3.61	....
Mar. 23–25	2.37	4.80	2.88	2.62	1.85	2.69	1.16	2.15	2.20	2.07	4.11	....	2.14	....
Mar. 28–29	4.01	1.80	4.75	1.18	5.52	1.53	4.10	....	....	1.10	1.96	....	4.19	....
Sept. 1–3	1.14	1.91	4.23	.94	1.32	3.69	....	1.00	....	.29	....	....	1.29	....
1904.														
May 16–20	.73	.12	.31	.35	1.26	1.23	.96	9.68	2.16	.53	2.27	....	1.65	....
June (all)	....	....	8.19	7.07	7.39	10.54	11.05	6.06	5.25	8.14	14.80	....	10.25	....
Aug. 6–10	1.71	....	1.20	....	.87	2.05	1.10	3.45	....	4.45	.29	....	.49	....
Sept. 6–12	1.80	3.50	2.15	....	2.35	4.18	2.73	2.41	....	.15	.12	....	.41	....
Sept. 22–24	.30	.94	1.30	4.00	1.98	2.03	.66	1.42	....	.56	.31	....	.66	....
Oct. 16–20	3.82	6.54	4.33	4.21	5.90	16.85	1.84	4.83	.08	.75	1.77	....	9.17	....
Nov. 10–13	1.88	.97	2.73	2.25	4.56	2.42	3.97	3.54	2.86	.53	1.13	....	2.51	....

1905.														
Jan. 6	.15	.30	.62	.64	.47	.01	.57	2.00	....	.07	.25	....	.30	....
Feb. 21-22	.48	.40	....	.56	....	.95	1.08	.51	....	....	....	....	.20	....
Mar. 21-25	.46	2.12	2.17	2.17	1.33	2.01	.74	1.32	1.00	....	.00	....	2.16	....
Apr. 20-23	.65	.42	.25	3.02	3.45	2.47	1.32	.50	1.05	7.38	2.93	....	1.91	....
May 24-28	.13	1.88	3.60	.17	2.30	2.95	2.33	3.70	5.11	....	1.11	....	2.96	....
July (all)	5.03	6.15	14.05	8.36	5.51	9.12	10.46	3.63	....	....	13.90	....	13.70	....
Sept. 21-30	12.32	8.45	2.71	5.51	4.84	8.61	5.10	5.68	....	....	4.31	....	4.18	....
Nov. 15-18	.66	2.69	2.54	2.75	.97	.43	1.70	.75	1.08	....	.74	....	3.22	....
Dec. 7-8	1.94	1.63	.77	1.25	....	7.63	1.04	4.69	1.80	....	.50	....	.65	....
Dec. 19-31	2.94	4.75	5.26	2.81	....	4.13	3.71	5.23	6.30	....	2.81	....	8.23	....
1906.														
Jan. 1-6	1.60	1.83	2.06	.30	.87	.47	1.51	3.20	5.40	....	.23	....	1.60	....
Jan. 21-25	3.60	3.63	3.97	1.31	....	1.60	2.04	.10	1.00	....	1.44	....	2.44	....
Feb. 7-12	.85	.63	.76	1.61	.81	2.02	2.60	2.18	4.08	....	.83	....	1.98	....
Mar. 29-31	.98	1.00	1.21	1.18	.53	.95	2.75	3.73	2.30	....	.42	....	.20	....
May 13-28	11.81	9.46	6.54	5.32	5.48	5.79	7.56	7.89	3.45	....	3.68	....	3.75	....
June (all)	9.89	11.75	10.21	3.95	12.05	11.90	12.30	8.60	....	....	11.00	....	9.36	....
Nov. 1-3	.10	.23	.16	1.01	3.08	4.52	4.21	7.26	....	....	.18	....	.03	....
1907.														
Mar. 10-12	.56	.27	1.37	1.68	1.49	3.13	2.23	1.36	.65	....	.60	....	1.64	....
May 31-June 2	4.15	3.30	3.24	3.83	....	2.65	4.37	2.52	1.00	....	4.99	....	4.86	....
June 25-30	3.79	4.25	2.77	3.07	....	3.44	3.27	3.40	1.55	....	3.04	....	2.83	....
July (all)	12.27	9.96	12.51	7.51	4.47	4.34	5.52	3.78	5.07	....	6.70	7.02	8.50	....
Oct. 6-11	.85	1.91	1.45	2.29	....	2.18	2.33	.50	....	....	.55	1.29	3.81	....
Dec. 13-14	2.65	1.00	.99	1.04	1.12	1.25	.50	.80	.48	....	.80	....	1.26	....
1908.														
Jan. 5-7	.30	1.09	1.61	1.77	.25	.03	....	.32	.48	....	.70	.33	.56	....
Jan. 11-13	1.25	2.05	1.77	.44	.58	.56	.89	.77	.80	....	.80	1.50	1.71	....
Apr. 27-30	1.60	2.31	2.34	1.54	.62	.21	1.10	1.33	1.39	....	.83	.47	.60	....
June (all)	2.11	4.84	4.32	7.85	5.93	7.06	10.92	9.75	5.98	....	13.75	8.03	....	....
July (all)	3.51	7.03	4.74	3.43	9.10	4.27	8.09	5.21	5.71	....	....	5.26	4.92	....
August (all)	7.48	7.04	9.40	8.57	7.51	9.20	5.33	7.76	....	....	9.14	18.24	....	....
September (all)	16.02	9.94	8.48	19.96	15.44	5.72	5.17	11.02	....	....	12.91	15.67	10.30	....
Oct. 27-28	.30	.23	.59	2.10	2.87	5.77	6.43	3.76	....	....	2.63	4.71	1.53	....
Nov. 10-14	1.43	2.31	2.08	4.39	4.04	6.64	4.35	.75	....	....	.20	1.11	2.38	....
1909.														
Jan. 5-6	1.40	1.17	.32	.40	1.81	.70	.47	.68	....	....	.43	.69	.23	....
Feb. 15-16	.47	.67	.35	.40	.11	.37	1.11	....	....	....	.01	....	1.70	....
Mar. 25	.30	.95	1.13	1.25	1.22	.49	.66	.40	....	....	....	.67	.50	....
Apr. 9-14	2.25	2.00	2.15	1.90	1.20	3.40	3.42	7.00	....	....	2.35	1.24	1.14	....
May 17-22	2.44	1.85	4.38	3.73	2.91	3.84	3.10	4.15	....	....	.47	5.61	4.73	....
July (all)	17.01	12.71	11.28	7.34	9.49	6.61	9.31	4.38	....	....	5.76	9.34	12.95	....
August (all)	8.89	9.44	9.53	6.04	6.25	4.53	7.01	8.34	....	....	14.59	11.75	11.91	....
Dec. 12-13	.10	.25	.62	.15	1.12	.50	.17	....	....	....	.13	.14	.11	....

TABLE 3.—*Storm precipitation*—Continued.

Date.	Clermont.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Jupiter.	Hypoluxo.	Miami.	Flamingo.	Marco.	Fort Myers.	Arcadia.	Avon Park.	Observation Island.
1910.														
Jan. 28–29	.60	.54	.80	.26	.23	.35	.27	....	....	....	1.58	.56	.45	....
Mar. 2–6	....	2.50	1.31	1.48	.65	6.31	2.41	....	....	....	.63	.63	1.93	....
July 19–21	.30	1.84	.18	1.49	3.95	1.93	2.21	1.37	....	....	1.88	.69	1.77	....
Oct. 13–19	11.70	10.39	7.90	8.46	8.72	14.36	22.49	13.50	....	....	9.94	8.97	9.27	....
1911.														
May 3–6	.45	.55	.18	.38	.50	....	3.07	2.75	....	....	2.16	1.53	.91	....
May 13–22	2.23	2.07	1.43	5.81	6.55	....	7.01	8.90	....	....	6.02	2.82	3.64	....
June 6–9	.88	2.35	4.30	1.65	1.30	....	.35	1.02	....	....	1.03	2.96	.57	....
June 17–20	2.97	2.00	.70	1.59	1.45	....	2.20	.37	....	....	3.47	1.14	2.76	....
Aug. 20–24	4.30	1.15	3.38	.38	.40	....	.34	.83	....	....	3.82	1.96	1.25	....
Sept. 22–28	.44	2.92	1.06	1.40	1.60	....	4.50	2.12	....	....	3.90	.79	.49	....
Oct. 13–19	.38	1.21	1.26	1.55	3.70	....	4.54	2.38	....	....	2.03	4.53	2.30	....
Nov. 28–30	3.90	3.40	2.27	.95	.10	....	....	.17	....	....	.17	.49	.74	....
1912.														
Jan. 9	1.00	1.25	1.35	1.16	.80	....	.45	.48	....	....	.62	1.70	1.36	....
Jan. 11–13	1.35	2.80	1.88	1.47	.60	....	1.45	1.09	....	....	.42	1.46	2.57	....
Jan. 30	.20	1.15	1.18	.65	.40	....	.35	.60	....	....	.58	.77	.88	....
Mar. 16–18	1.10	.35	.51	.41	.80	....	.30	2.26	....	....	2.70	2.08	....	0.66
May 20–24	2.47	6.28	1.29	.14	2.20	....	9.78	6.28	....	....	....	1.45	....	1.70
June 6–11	11.75	5.83	7.54	4.05	6.20	....	18.85	5.25	....	....	....	10.01	9.40	7.15
Sept. 17–23	3.05	3.50	1.97	3.68	2.60	....	1.79	1.02	....	....	4.58	2.01	4.11	2.27
Oct. 1–5	2.40	3.61	2.05	1.89	2.40	....	.70	.65	....	....	2.67	2.35	2.22	1.06
Nov. 20–22	1.70	1.43	2.05	1.85	1.00	....	1.20	7.75	....	....	.49	.53	.93	.42
Total	272.66	285.79	279.30	218.95	244.43	278.95	315.05	288.75	88.98	64.09	268.75	142.50	230.07	13.26
Average	3.24	3.28	3.14	2.96	3.26	3.93	3.89	3.61	2.54	2.91	3.20	3.65	3.28	1.66

The foregoing table shows a close agreement in average storm rainfall for the entire period at the several stations. Comparison of the figures for each storm will reveal no degree of uniformity nor any indication whatsoever as to the trend of storm intensity. The heaviest catch in each storm appears to be distributed without discrimination, first at one point of observation and then at another. The final result as summed up in the average shows that at all the stations, with the exception of Flamingo, Marco, and Observation Island, where the observations have been comparatively few in number, the mean storm rainfall is between 3 and 4 inches. Moreover, the difference in averages are so small that one may assume without liability to important error that the mean of observations made during any one storm reasonably represents the actual precipitation over the Everglades, and the figures so derived may be used without correction. This refers, of course, to the general storms taking place in the whole area and not to the showers which are of limited catchment area. It is true that one might, with the foregoing data, contrive and construct divers distribution schemes and spectacular weightings, but these would be, after all, an imaginative exercise unwarranted by the data and of no practical value in the conclusions.

It may be said with justification that the final results in the foregoing table are but crude averages; that at some stations the records are numerous and at other stations comparatively few; that records are missing in the several storms, now at one station, now at another, and therefore that the comparatively close agreement of means may be an accident—the algebraic sum of many badly weighted units. The point is sufficiently important to warrant a reasonable test. Therefore the following figures have been derived from thoroughly comparable records, which cover the same periods and in which no records are missing.

Comparison of 65 storms occurring at Orlando, Jupiter, and Fort Myers from January 16, 1899, to October 19, 1910:

	Orlando.	Jupiter.	Fort Myers.
Total fall	231.90	259.63	213.81
Mean	3.57	3.99	3.29

These three stations are located at the points of a triangle which covers the Lake Okeechobee and northern Everglades region. The first sums up the interior catch, the second that of the Atlantic coast, and the third that of the Gulf.

In a similar manner, and by quadrilateral location, the following stations encompass almost the entire district, and the results are the summation of 66 storms, extending from February 20, 1902, to November 22, 1912:

	Clermont.	Malabar.	Miami.	Fort Myers.
Total	206.72	199.41	221.22	203.73
Mean	3.13	3.02	3.35	3.08

The next comparison is a combination of six stations, two north, two east, and two west, consisting of 50 storms, extending from September 1, 1902, to November 22, 1912, which gives the following summation:

	Clermont.	Orlando.	Fort Pierce.	Hypoluxo.	Fort Myers.	Avon Park.
Total	151.25	153.10	152.59	158.36	141.16	160.81
Mean	3.03	3.06	3.06	3.16	2.82	3.20

Extending the comparison to cover all the long-term and continuously maintained stations, the following results cover 54 storms, from September 1, 1902, to November 22, 1912:

	Clermont.	Orlando.	Kissimmee.	Malabar.	Fort Pierce.	Hypoluxo.	Miami.	Fort Myers.	Avon Park.
Total	170.87	172.70	162.19	158.12	167.49	182.46	180.35	155.42	172.93
Mean	3.13	3.21	3.00	2.93	3.10	3.37	3.33	2.87	3.20

A final record includes the station at Arcadia, operation of which was started in July, 1907, and includes 29 storms.

	Clermont.	Orlando.	Kissimmee.	Miami.	Malabar.	Fort Pierce.	Hypoluxo.	Fort Myers.	Arcadia.	Avon Park.
Total	99.51	94.07	89.33	91.11	90.94	87.25	99.86	93.69	94.35	92.13
Mean	3.43	3.24	3.08	3.14	3.13	3.01	3.44	3.23	3.25	3.18

The general uniformity of average storm precipitation will be noted in the foregoing statements. Lest there should be some misunderstanding of their purport, the fact should be emphasized that the actual average values above reported have little or no significance. The whole purpose is to show by relative values, first, that, through a period of years, marked differences in general or extensive storm precipitation as measured at the several rainfall stations are largely compensated; second, that because of this fact the application of a system of weighting results to secure a weighted storm precipitation is not necessary; third, that in the absence of long-term precipitation records in the central Everglades the most reasonable and tenable assumption is that the direct means of all recorded storm catchments represents the general storm precipitation over the entire area. Finally it should be stated that the foregoing conclusions refer only to storm precipitation and not to long-term totals or averages.

EVAPORATION.

The measurement of evaporation is probably the most unsatisfactory and uncertain process in hydrometric work. The many experiments and series of observations that have been made throughout the civilized world apply only to the particular conditions governing each and are almost surely erroneous for every other condition. As the natural phenomena, consisting largely of temperature, wind velocity, barometric pressure, dew point, character of vegetative or other cover, vapor pressure, etc., not only vary from place to place but from hour to hour in the same place, the problem is exceedingly complex. Moreover, some of the factors governing the rate of evaporation are not as well understood nor as accurately measurable as they should be if good results are to be obtained. Therefore the best that can be done without the expenditure of practically unlimited time and money is to select a set of conditions which may roughly approximate the average and apply the results secured with a large measure of discretion.

The observations which have the closest application to the conditions prevailing in the Everglades are those secured at Crowley, La., by the Bureau of Plant Industry, United States Department of Agriculture, under the direction of Dr. Lyman J. Briggs, physicist in charge. These measurements were made from a free water surface in a circular pan 6 feet in diameter, which was sunk in the ground. The water level in the pan was maintained approximately at the level of the ground surface.

The results for the years 1910 to 1913, inclusive, are as follows:

	1910	1911	1912	1913		1910	1911	1912	1913
January	1.45	1.41	1.96	1.57	August	5.40	5.41	5.75	....
February	2.37	2.89	3.00	2.61	September	4.58	4.15	4.17	....
March	3.29	3.95	3.30	2.61	October	4.31	4.39	4.00	....
April	5.66	5.81	4.03	5.10	November	2.68	3.10	2.46	....
May	5.87	5.32	5.69	5.70	December	2.42	2.88	2.10	....
June	5.78	6.89	5.93	....					
July	5.56	5.56	5.08	....	Total	49.37	51.76	47.47	....

According to the foregoing table the annual evaporation at Crowley, La., is about 50 inches, with high months extending from April to August, inclusive. Review of the general climatic conditions at Crowley and in the Everglades region shows that while the two are at some variance, the differences are not sufficiently marked to make very wide departures in monthly evaporation. If the Crowley results apply even approximately to Everglades conditions it is apparent that the assumptions made for original State operations were more than twice too high.

Florida evaporation.—As soon as possible after the beginning of the present investigations, preparations were made to measure evaporation on the Everglades. The complexities of the problem are accentuated there by reason of the varying surface conditions. Lake Okeechobee presents a water surface of 730 square miles. In addition to this there is probably as large an aggregate water surface represented by other lakes and sloughs. At times almost the entire Everglades region is covered with water, and so the conditions vary from comparatively dry to entirely wet. The factors governing evaporation are therefore quite as variable.

In planning the work the commission was greatly assisted by the advice and counsel of Prof. Charles F. Marvin, now Chief of the United States Weather Bureau, and by Dr. Lyman J. Briggs, physicist of the Bureau of Plant Industry, United States Department of Agriculture. It was decided that in view of the unsatisfactory state of the science and the limited time at the commission's disposal, the most purposeful course would be to secure that which would most nearly represent the average rate of evaporation. This condition appeared to be best satisfied by setting evaporation pans in the wet muck and operating them as has been described in the case of the Crowley observations. By courtesy of the United States Weather Bureau, two standard pans and measuring instruments were loaned to the commission and installed, one near the edge of Lake Okeechobee at Rita and the other near the South New River Canal at Zona. The results which appear in the following table are believed to be higher than the actual evaporation from the Everglades water surfaces and lower than that from the uncovered saw grass surfaces. It is especially to be regretted that the commission was obliged to prepare this report before a complete year of records was collected.

Evaporation at Rita and Zona, Fla.

	Rita.	Zona.
1913.	*Inches.*	*Inches.*
June 21	0.27	....
June 22	.16	....
June 23	.19	....
June 24	.50	....
June 25	.21	....
June 26	.31	0.13
June 27	.17	.21
June 28	.28	.13
June 29	.21	.15
June 30	.21	....
Total	2.51	.62
July 1	.24	.15
July 2	.22	.22
July 3	.19	.16
July 4	.22	.09
July 5	.24	.28
July 6	.18	.24
July 7	.21	.26
July 8	.15	.19
July 9	.23	.20
July 10	.17	.17
July 11	.23	.24
July 12	.19	.22
July 13	.17	.24
July 14	.04	.24
July 15	.26	.26
July 16	.24	.20
July 17	.20	.20
July 18	.19	.20
July 19	.21	.22
July 20	.22	.24
July 21	.24	.16
July 22	.19	.17
July 23	.16	.21
July 24	.22	.23
July 25	.09	.17
July 26	.11	.17
July 27	.24	.21
July 28	.21	.21
July 29	.21	.27
July 30	.19	.24
July 31	.20	.22
Total	6.06	6.48
August 1	.14	.37
August 2	.22	.15
August 3	.18	.08
August 4	.17	.23
August 5	.15	.10
August 6	.11	.06
August 7	.15	.16
August 8	.14	.16
August 9	.22	.22
August 10	.14	.21
August 11	0.20	0.17
August 12	.11	.20
August 13	.17	.20
August 14	.18	.23
August 15	.19	.19
Aug. 16	.22	.13
Aug. 17	.20	.32
Aug. 18	.26	....
Aug. 19	....	.27
Aug. 20	....	.09
Aug. 21	....	.09
Aug. 22	.05	....
Aug. 23	.21	.00
Aug. 24	.08	.09
Aug. 25	.18	.02
Aug. 26	.04	.18
Aug. 27	.09	.38
Aug. 28	.15	.24
Aug. 29	.13	.09
Aug. 30	.12	.17
Aug. 31	.15	.07
Total	4.35	4.87
Sept. 1	.29	....
Sept. 2	.15	....
Sept. 3	.18	....
Sept. 4	.11	....
Sept. 5	.06	....
Sept. 6	.03	....
Sept. 7	.05	....
Sept. 8	.09	....
Sept. 9	.21	....
Sept. 10	.18	....
Sept. 11	.23	....
Sept. 12	....	....
Sept. 13	....	....
Sept. 14	.11	....
Sept. 15	.12	....
Sept. 16	.07	....
Sept. 17	.15	....
Sept. 18	.07	....
Sept. 19	.17	....
Sept. 20	....	....
Sept. 21	.13	....
Sept. 22	.25	....
Sept. 23	.30	....
Sept. 24	.20	....
Sept. 25	.11	....
Sept. 26	.07	....
Sept. 27	.11	....
Sept. 28	.17	....
Sept. 29	.13	....
Total	4.52	....

The foregoing figures indicate a rate of evaporation similar to that at Crowley, La., during the summer months. Its significance in practical drainage plans will now be considered.

The highest recorded daily rate of evaporation in the above record is 0.50 inch at Rita on June 24; the next highest is 0.37 inch at Zona on August 1. The average rate is much lower. Emphasis should, however, be laid on the fact that so far as the local drainage of land is concerned, the average rate is not significant. As has already been expressed in the discussion of rainfall, the point to be considered is the individual storm. It is the storm run-off that must be carried away without prolonged overflow, and having provided sufficient canal capacity for this the average run-off will be amply provided for. Now during, and shortly after, storms it is apparent that the rate of evaporation must be at its lowest point. As a factor in modifying local storm run-off it is quite negligible. If evaporation on the Everglades were intense as it is, for example, in the Salton Basin of California, it would be a part of wisdom to make some allowances therefor. Inasmuch as on the days of high storm run-off it can hardly exceed and probably never equals 0.01 inch, the amount is relatively too small to warrant any allowance in the practical canal capacities adopted for the Everglades. In the original plans adopted by the State it was assumed that the greater part of the estimated run-off would be eliminated in this way, thereby greatly reducing the estimated necessary capacity of the drainage canals. There is no measure of justification for evaporation allowance in calculating storm run-off canal capacity of drainage ditches and none will be made in this report.

The control of Lake Okeechobee and its utilization as a storage reservoir necessitates consideration of evaporation. The case is unlike that discussed immediately above. In the drainage of lands for agriculture, the manifest effort is to get rid of surplus water. In storage considerations the purpose is to save all the water possible and to use it during dry seasons for navigation, water power, or irrigation. Therefore, in any such scheme due allowance must be made for that portion which is lost by evaporation. Evaporation losses are practically continuous and cumulative. It will therefore be necessary to determine what, if any, effect on ultimate storage utilization, evaporation will produce. Of course, no finally adjusted determination is possible because no adequate measurements have been made in the Everglades. Therefore, it will be necessary to make certain assumptions which shall be so conservative as to render safe the final conclusions.

Available information has already been set forth. Undoubtedly the recorded evaporation at Crowley, La., is not precisely the same as that which takes place in the Everglades. Nevertheless, the similarity of climatic and physiographic conditions, together with the relative agreement of the few coincident observations that have been recorded in both places justifies the assumption that the differences in rate of evaporation may not be large. If it be assumed in the present calculations that they are the same, and if the final results be interpreted broadly, the results should be satisfactory. Accordingly, the evaporation standards herein adopted are the monthly means of the results recorded at Crowley for the years 1910 to 1912, inclusive, averaged with a combination of the Crowley and Everglades records for the year 1913.

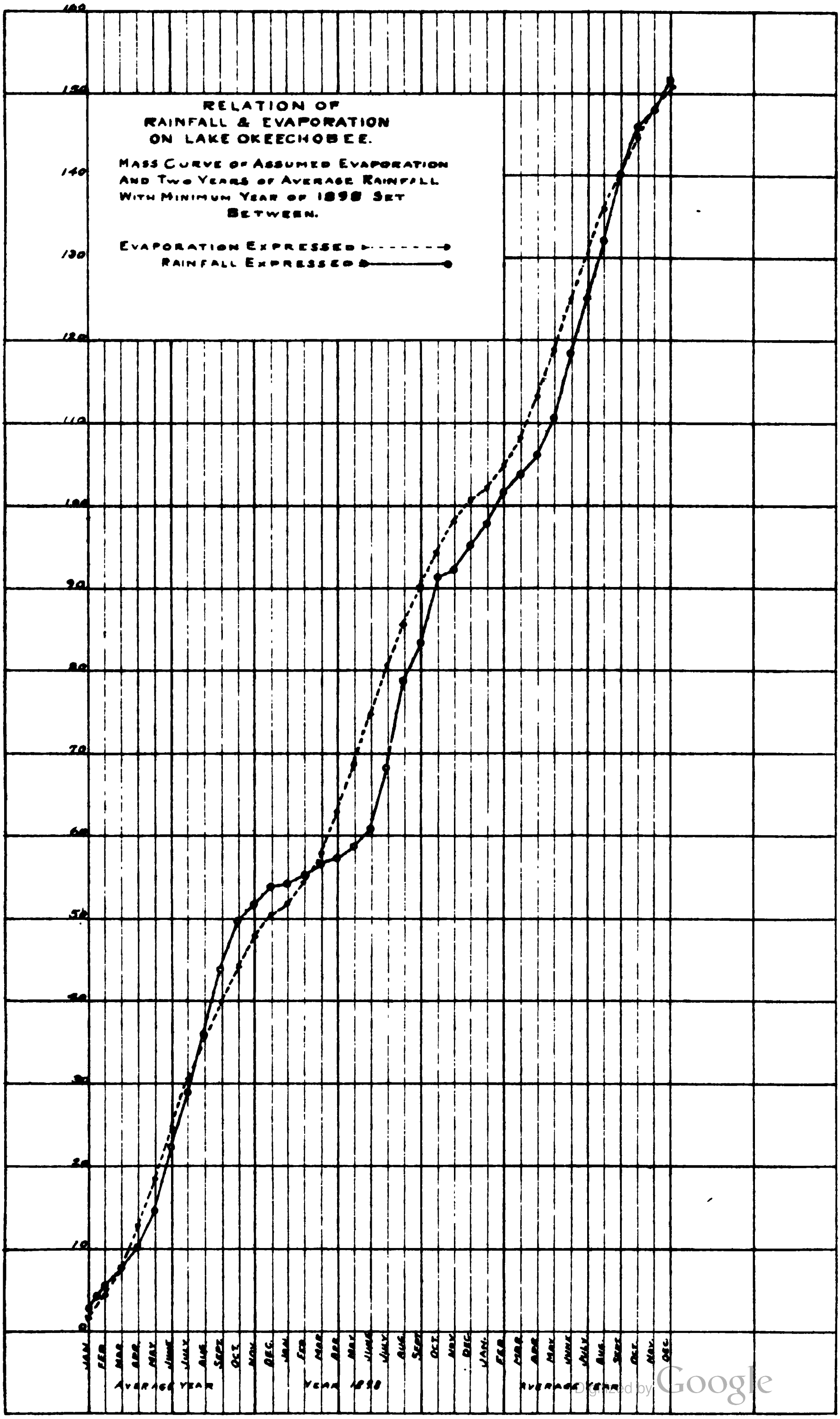
Examination of Table 1 (see pp. 19–22) containing the records of monthly rainfall for the past 25 years at the long-term stations surrounding the Everglades shows that the year 1898 is the lowest in the period. This year, therefore, presents the most severe evaporation loss conditions yet recorded. Estimates based on that year will certainly be conservative for any other year of record and the future will rarely, if ever, produce a year in which the rainfall is less.

In comparing evaporation with rainfall in any particular year, it is not sufficient to use that year alone because the hold-over storage or the rainfall in the year previous and in the year subsequent will usually affect the conclusions, The years 1897 and 1899 were years of large rainfall. To use these years in connection with the minimum year of 1898 would possibly make the result appear more favorable than true conservatism would warrant. Therefore, it will be assumed that the years previous and subsequent to the year of 1898 are years of average precipitation. Following the course of procedure, above discussed, the elements entering into the estimate are as follows:

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Evaporation	1.59	2.72	3.28	5.15	5.64	6.20	5.75	5.15	4.35	4.23	3.75	2.47
Rainfall, 1898	0.26	1.10	1.31	0.61	1.53	2.18	7.26	10.58	4.69	7.75	1.01	2.14
Mean rainfall	2.68	2.76	2.17	2.40	4.46	7.73	6.72	6.81	8.06	5.80	2.17	2.11

The foregoing factors have been plotted as mass curves on the accompanying diagram, entitled "Relation of rainfall to evaporation on Lake Okeechobee." The ordinates represent vertical inches of rainfall and evaporation. The abscissas represent monthly periods, the first and third being the average rainfall years, while the second is the minimum year of 1898. By this arrangement we have the minimum year set down between two average years. The evaporation curve is, of course, identical for all three years. The diagram shows that the evaporation is always in excess of the rainfall during the year 1898. The difference is, however, comparatively small. Indeed, the maximum excess of evaporation over rainfall, as shown by the longest ordinate between the two curves, occurs in June, 1898, and amounts to 1.4 inches. During a part of the three-year period the rainfall is in excess of the evaporation, and therefore has a certain compensating effect. It will now be necessary to determine what would be the maximum effect of this rainfall deficiency on practical storage evaporation.

One and four-tenths inches on 730 miles of Lake Okeechobee surface equals 2,375,000 cubic feet. The month of June has 2,592,200 seconds. Therefore, the average loss by evaporation for that month will be equivalent to 918 cubic feet per second. As will later be shown, the aggregate discharge from Lake Okeechobee during the low-water season of 1913 through the Three-Mile, North, Miami, and Hillsborough Canals was approximately 2,000 cubic feet per second. It is therefore apparent that if less than half of this amount were stored in the lake in 1898 the surface elevation thereof would have been held practically uniform so far as evaporation loss is concerned. The area tributary to Lake Okeechobee certainly contributes water in the driest seasons equal to at least three times that necessary for compensating evaporation losses. In view of the extreme conserva-



RELATION OF RAINFALL & EVAPORATION ON LAKE OKEECHOBEE.

MASS CURVE OF ASSUMED EVAPORATION AND TWO YEARS OF AVERAGE RAINFALL WITH MINIMUM YEAR OF 1898 SET BETWEEN.

WEBB & BOCORSELSKI, INC., WASHINGTON, D. C.

tism used in the foregoing assumptions, it is believed that there need be no hesitation in concluding that in years of high rainfall sufficient water falls directly on the lake to amply compensate evaporation losses; that in the average year there is still an excess of rain; that in the year of minimum rainfall the maximum compensation for such losses is approximately 900 cubic feet per second, and this for only comparatively short periods.

EVERGLADES RUN-OFF.

The run-off characteristics of the Everglades are yet to be precisely determined. The work of this commission would, had it been allowed to continue for a period of years, have furnished a satisfactory basis for close determination. The necessity for an early closing of the investigations has rendered it impossible to present fixed conclusions. It is the commission's desire to urge with all possible emphasis that the honorable board provide liberally for the further maintenance of intensive hydrometric work. The successful drainage of this or any other area can be accomplished only when surplus water is conducted away from the land. It is therefore fundamental that the amount of water that must necessarily be so conducted be well determined. Then, and only then, can a canal system be so proportioned that it will surely fit the requirements. The only way to determine the amount of water is to measure it, and such measurements must be maintained over an extended period. The type of work is different from that of a land survey or the erection of a structure. In such cases completion can be hastened up to a certain degree by increasing the working force. In the determination of run-off, however, the work can progress only as fast as the seasons go by, and there is no assurance that any future season will produce the particular conditions of rainfall and run-off that will permit of rounding up the conclusions on the subject. The honorable board can proceed with intensive hydrometric work with a comparatively small expenditure, and there is no way by which it could expend money with greater ultimate benefit to the State.

The commission submits the foregoing emphatic statement because it has severely appreciated the difficulties occasioned by the lack of such data. It had no expectation in the beginning that it could, in the short period designated in its contract, determine finally the run-off characteristics of the Everglades. That which it did hope to do was to get certain fundamental factors by which it could directly determine with some reasonable degree of accuracy the necessary canal capacities, so that the State could with confidence proceed with its plans, assured that the only changes subsequently necessary would be the minor and inexpensive ones, advisable in consequence of more highly refined run-off data secured in consequence of later investigations. All things necessary to accomplish the purpose were arranged by the commission, but the contract period has not furnished the most necessary factors of all—heavy rains and high flood waters. The entire six months have been practically rainless. Against such a misfortune neither this commission nor any other that might be organized could prevail.

It has therefore been necessary to construct the run-off portion of this report—first, with the few hydrometric facts that could be obtained; second, by taking advantage of every correlated and confirmatory incident that has occurred in the past; third, by generalizing and specializing broadly from experience and observation in other places; and, finally, by approaching all conclusions in a conservative way, making due allowances for all apparently incomplete and unknown facts. The commission believes that its conclusions are as safe as could be made with the data at hand. It presents them with all due confidence and would not hesitate to proceed with the work along the course laid down. In so doing, however, it would reserve the right to pursue hydrometric investigations at least throughout a high-water season and modify its first plans accordingly. Therefore, the commission can not and does not guarantee the correctness of the run-off findings here presented. Such a guaranty would merely be an assumption of infallibility and a violation of truth. It is almost inevitable that further hydrometric studies, which the honorable board is in duty bound to make, will dictate some modifications of this report's conclusions. We think those modifications will be small, but there can be no assurance that they may not be fairly wide. So far as the run-off conclusions in this report are subsequently confirmed by actual data, and only so far, does this commission defend them. This statement can not be made too emphatic.

Unusual run-off factors in the Everglades: There is probably no more difficult place on this continent in which to determine run-off than in the Everglades. Its general inaccessibility, its lack of perceptible grade, its practically unknown geology, the variability of its muck cover, and the unexplored influence of Lake Okeechobee on underground flow, all present grave uncertainties. The underground water problem is an unknown factor; whether through the porous and probably cavernous limestone that underlies the Everglades the waters of Lake Okeechobee have access, and if they do, how extensive is their journey, are vitally important points which will require years of study and observation. More important than all else, however, is the fact that in the day when Everglades muck is drained and cultivated the rate at which it will give up its water into canals and ditches will be markedly different from that which now prevails. The virgin muck is a coarsely fibrous substance; after cultivation has taken place for several seasons it becomes a fine-grained soil of almost unexampled productivity. Thus the run-off factors that we are now able to determine will, after cultivation, not apply to the new conditions. Happily there is every evidence that the soil will be more retentive of water after cultivation than it is now. Therefore the canals that will be necessary to drain the Glades in the first instance will be ample for subsequent conditions. In view of all of the above, let no one vainly imagine that this report or the report of any commission similarly instructed can be the last word on the subject. On the contrary, such a report can be only the beginning of information. Patient and continuous study by the State's officers, and especially by the farmer, must proceed for a generation. Concerning all soil, the farmer has much to learn, but especially concerning muck soil. This commission in its goings about the Everglades has gathered from old residents and from apparently reputable observers and experimenters more contradictory information about muck than the commission's members have confronted about any other subject in all their professional lives. Confusion seems to be unbounded, and about every disputed point there turns a factor affecting run-off.

Plan of hydrometric investigations.—In laying out the work of measuring run-off the two familiar Everglades problems presented themselves, viz, control of Lake Okeechobee and the local drainage of muck lands. For the first it became necessary to determine the amount of water contributed to Lake Okeechobee; for the second the need was to ascertain the relation of rainfall to run-off in the Everglades. Obviously the most direct way to measure the amount of water flowing into a lake is to observe the flow of its tributaries and apply a determined factor to the area that contributes directly. This course proved impossible in the present instance because the directly contributing area was not determinable in the time and with the funds available to the commission. More important than this, however, was the fact that the streams tributary to the lake, and especially the principal one, Kissimmee River, afford no suitable measurement section where the channels are sufficiently uniform and the banks are high enough to carry the extreme floods. Therefore it became necessary to determine this factor from the other end, viz, to measure the water flowing out of well-defined channels from the lake. Accordingly measurement stations were established at the heads of the four canals leading from the lake—Three-Mile, Miami, North New River, and Hillsborough. The canal last named has not, at the date of writing, been cut through to the coast, yet, as figures subsequently given will show, it has a large discharge, the water probably flowing out over some of the lower glades or into convenient sloughs. All of the discharge from the lake up to the point of broad overflow is measured at these stations, except the unknown but probably relatively constant amount that seeps out to the south underground.

The amount of water discharged from Lake Okeechobee is shown by Table No. 4.

TABLE NO. 4.—*Discharge from canals leading from Lake Okeechobee.*

[Cubic feet per second.]

Date.	Three-mile Canal.		South New River Canal.		North New River Canal.		Hillsborough Canal.		Total from lake.
	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	
1913.									
May 15	20.00	708	20.00	555	20.00	625	20.00	437	2,325
16	19.97	678	19.97	546	19.97	616	19.97	435	2,295
17	19.93	685	19.93	532	19.93	605	19.93	432	2,254
18	19.91	679	19.91	524	19.91	600	19.91	431	2,234
19	19.90	675	19.90	521	19.90	596	19.90	430	2,222
20	19.88	669	19.88	514	19.88	591	19.88	429	2,203
21	19.87	666	19.87	510	19.87	588	19.87	428	2,192
22	19.86	663	19.86	507	19.86	585	19.86	428	2,183
23	19.88	669	19.88	514	19.88	591	19.88	429	2,203
24	19.93	685	19.93	532	19.93	605	19.93	432	2,254
25	19.97	698	19.97	546	19.97	616	19.97	435	2,295
26	20.00	708	20.00	555	20.00	625	20.00	437	2,325
27	20.01	712	20.01	560	20.01	628	20.01	438	2,338
28	20.00	708	20.00	555	20.00	625	20.00	437	2,325
29	19.99	706	19.99	552	19.99	622	19.99	436	2,316
30	19.98	702	19.98	549	19.98	620	19.98	435	2,306
31	19.93	685	19.93	532	19.93	605	19.93	432	2,254
Total		11,716		9,104		10,343		7,361	38,524
Mean		689		535		608		433	2,266
Maximum		712		560		628		438	2,338
Minimum		663		507		585		428	2,183

Table No. 4.—*Discharge from canals leading from Lake Okeechobee*—Continued.

Date.	Three-mile Canal.		South New River Canal.		North New River Canal.		Hillsborough Canal.		Total from lake.
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	
1913.									
June 1	19.95	691	19.95	538	19.95	611	19.95	434	2,274
2	19.92	682	19.92	528	19.92	603	19.92	431	2,244
3	19.87	666	19.87	510	19.87	588	19.87	428	2,192
4	19.84	656	19.84	500	19.84	580	19.84	426	2,162
5	19.84	656	19.84	500	19.84	580	19.84	426	2,162
6	19.80	644	19.80	485	19.80	568	19.80	424	2,121
7	19.81	646	19.81	489	19.81	571	19.81	424	2,130
8	19.84	656	19.84	500	19.84	580	19.84	426	2,162
9	19.87	666	19.87	510	19.87	588	19.87	428	2,192
10	19.93	685	19.93	532	19.93	605	19.93	433	2,255
11	19.97	698	19.97	546	19.97	616	19.97	435	2,295
12	19.86	663	19.86	507	19.86	585	19.86	428	2,283
13	19.96	694	19.96	542	19.96	614	19.96	434	2,284
14	19.93	685	19.93	532	19.93	605	19.93	433	2,255
15	19.87	666	19.87	510	19.87	588	19.87	428	2,192
16	19.86	663	19.86	507	19.86	585	19.86	428	2,183
17	19.78	637	19.78	479	19.78	562	19.78	422	2,100
18	19.75	627	19.75	468	19.75	554	19.75	420	2,069
19	19.75	627	19.75	468	19.75	554	19.75	420	2,069
20	19.71	614	19.71	454	19.71	542	19.71	418	2,028
21	19.68	605	19.68	444	19.68	534	19.68	416	1,999
22	19.67	601	19.67	440	19.67	531	19.67	415	1,987
23	19.63	588	19.63	426	19.63	519	19.63	412	1,945
24	19.59	575	19.59	411	19.59	508	19.59	410	1,904
25	19.58	572	19.58	408	19.58	505	19.58	409	1,894
26	19.59	575	19.59	411	19.59	508	19.59	410	1,904
27	19.58	572	19.58	408	19.58	505	19.58	409	1,894
28	19.59	575	19.59	411	19.59	508	19.59	410	1,904
29	19.61	582	19.61	418	19.61	513	19.61	411	1,924
30	19.64	591	19.64	429	19.64	522	19.64	413	1,955
Total	....	19,058	....	14,311	....	16,832	....	12,661	62,862
Mean	....	635	....	477	....	561	....	422	2,095
Maximum	....	698	....	546	....	616	....	435	2,295
Minimum	....	572	....	408	....	505	....	409	1,894
July 1	19.64	591	19.64	429	19.64	522	19.64	413	1,955
2	19.64	591	19.64	429	19.64	522	19.64	413	1,955
3	19.64	591	19.64	429	19.64	522	19.64	413	1,955
4	19.62	585	19.62	422	19.62	516	19.62	412	1,935
5	19.60	578	19.60	415	19.60	510	19.60	411	1,914
6	19.58	572	19.58	408	19.58	505	19.58	409	1,894
7	19.59	575	19.59	411	19.59	508	19.59	410	1,904
8	19.60	578	19.60	415	19.60	510	19.60	411	1,914
9	19.61	581	19.61	418	19.61	513	19.61	411	1,923
10	19.61	581	19.61	418	19.61	513	19.61	411	1,923
11	19.63	588	19.63	426	19.63	519	19.63	413	1,946
12	19.62	585	19.62	422	19.62	516	19.62	412	1,935
13	19.61	581	19.61	418	19.61	513	19.61	411	1,923
14	19.59	575	19.59	411	19.59	508	19.59	410	1,904
15	19.57	569	19.57	404	19.57	502	19.57	409	1,884
16	19.59	575	19.59	411	19.59	508	19.59	410	1,904
17	19.60	578	19.60	415	19.60	510	19.60	411	1,914
18	19.57	569	19.57	404	19.57	502	19.57	409	1,884
19	19.54	559	19.54	394	19.54	494	19.54	407	1,854
20	19.56	565	19.56	401	19.56	499	19.56	408	1,873
21	19.52	552	19.52	387	19.52	488	19.52	405	1,832
22	19.49	543	19.49	377	19.49	479	19.49	403	1,802
23	19.51	549	19.51	384	19.51	485	19.51	405	1,823
24	19.52	553	19.52	387	19.52	488	19.52	405	1,833
25	19.52	553	19.52	387	19.52	488	19.52	405	1,833
26	19.53	556	19.53	390	19.53	491	19.53	406	1,843
27	19.49	543	19.49	377	19.49	479	19.49	403	1,802
28	19.44	527	19.44	358	19.44	465	19.44	400	1,750
29	19.43	523	19.43	355	19.43	462	19.43	399	1,739
30	19.39	511	19.39	339	19.39	450	19.39	397	1,697
31	19.36	501	19.36	329	19.36	442	19.36	395	1,667
Total	....	17,478	....	12,370	....	15,429	....	12,637	57,914
Mean	....	563	....	399	....	497	....	407	1,868
Maximum	....	591	....	429	....	522	....	413	1,955
Minimum	....	501	....	329	....	442	....	395	1,667

TABLE No. 4.—*Discharge from canals leading from Lake Okeechobee*—Continued.

Date.	Three-mile Canal.		South New River Canal.		North New River Canal.		Hillsborough Canal.		Total from lake.
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	
1913.									
Aug. 1	19.38	508	19.38	336	19.38	448	19.38	396	1,688
2	19.39	511	19.39	339	19.39	450	19.39	397	1,697
3	19.41	517	19.41	348	19.41	456	19.41	398	1,719
4	19.46	533	19.46	366	19.46	470	19.46	401	1,770
5	19.47	536	19.47	370	19.47	473	19.47	402	1,781
6	19.47	536	19.47	370	19.47	473	19.47	402	1,781
7	19.48	540	19.48	373	19.48	476	19.48	403	1,792
8	19.45	530	19.45	362	19.45	468	19.45	401	1,761
9	19.40	514	19.40	344	19.40	453	19.40	397	1,708
10	19.37	505	19.37	332	19.37	444	19.37	395	1,676
11	19.35	498	19.35	325	19.35	439	19.35	394	1,656
12	19.32	488	19.32	314	19.32	430	19.32	392	1,624
13	19.32	488	19.32	314	19.32	430	19.32	392	1,624
14	19.31	485	19.31	310	19.31	427	19.31	391	1,613
15	19.31	485	19.31	310	19.31	427	19.31	391	1,613
16	19.33	491	19.33	318	19.33	433	19.33	393	1,635
17	19.33	491	19.33	318	19.33	433	19.33	393	1,635
18	19.32	488	19.32	314	19.32	430	19.32	392	1,624
19	19.31	485	19.31	310	19.31	427	19.31	391	1,613
20	19.31	485	19.31	310	19.31	427	19.31	391	1,613
21	19.24	462	19.24	284	19.24	408	19.24	387	1,541
22	19.30	481	19.30	306	19.30	425	19.30	391	1,603
23	19.28	475	19.28	298	19.28	419	19.28	389	1,581
24	19.28	475	19.28	298	19.28	419	19.28	389	1,581
25	19.31	485	19.31	310	19.31	427	19.31	391	1,613
26	19.38	508	19.38	336	19.38	448	19.38	396	1,688
27	19.37	505	19.37	332	19.37	445	19.37	395	1,677
28	19.40	514	19.40	343	19.40	453	19.40	397	1,707
29	19.42	520	19.42	350	19.42	459	19.42	399	1,728
30	19.41	517	19.41	347	19.41	456	19.41	398	1,718
31	19.41	517	19.41	347	19.41	456	19.41	398	1,618
Total	....	15,573	....	10,334	....	13,729	....	12,242	51,878
Mean	....	502	....	333	....	443	....	395	1,673
Maximum	....	540	....	373	....	476	....	403	1,792
Minimum	....	462	....	284	....	408	....	387	1,541
Sept. 1	19.37	505	19.37	332	19.37	444	19.37	395	1,676
2	19.33	491	19.33	318	19.33	433	19.33	393	1,635
3	19.32	488	19.32	314	19.32	430	19.32	392	1,624
4	19.30	482	19.30	306	19.30	425	19.30	391	1,604
5	19.28	475	19.28	298	19.28	419	19.28	389	1,581
6	19.29	478	19.29	302	19.29	422	19.29	390	1,592
7	19.32	488	19.32	314	19.32	430	19.32	392	1,624
8	19.32	488	19.32	314	19.32	430	19.32	392	1,624
9	19.37	505	19.37	332	19.37	444	19.37	395	1,676
10	19.37	505	19.37	332	19.37	444	19.37	395	1,676
11	19.38	507	19.38	338	19.38	448	19.38	396	1,689
12	19.35	498	19.35	325	19.35	439	19.35	394	1,656
13	19.34	495	19.34	321	19.34	436	19.34	393	1,645
14	19.28	475	19.28	298	19.28	419	19.28	389	1,581
15	19.26	468	19.26	291	19.26	413	19.26	388	1,560
16	19.21	452	19.21	276	19.21	400	19.21	385	1,513
17	19.21	452	19.21	276	19.21	400	19.21	385	1,513
18	19.18	442	19.18	267	19.18	390	19.18	383	1,482
19	19.19	446	19.19	271	19.19	393	19.19	383	1,493
20	19.24	462	19.24	284	19.24	407	19.24	387	1,540
21	19.30	482	19.30	306	19.30	425	19.30	391	1,604
22	19.34	495	19.34	321	19.34	436	19.34	393	1,645
23	19.38	508	19.38	338	19.38	448	19.38	396	1,690
24	19.37	505	19.37	332	19.37	444	19.37	395	1,676
25	19.29	478	19.29	302	19.29	422	19.29	390	1,592
26	19.22	454	19.22	279	19.22	402	19.22	385	1,520
27	19.15	433	19.15	260	19.15	381	19.15	381	1,455
28	19.30	482	19.30	306	19.30	425	19.30	391	1,604
29	19.07	407	19.07	240	19.07	359	19.07	375	1,381
30	19.06	404	19.06	238	19.06	356	19.06	375	1,373
Total	....	14,250	....	9,031	....	12,564	....	11,679	47,524
Mean	....	475	....	301	....	419	....	389	1,584
Maximum	....	508	....	338	....	448	....	396	1,690
Minimum	....	404	....	238	....	356	....	375	1,373

For the purpose of determining the amount of water draining from Everglade lands, stations were established as follows: North New River Canal, at a point midway between head and foot, or about 30 miles from the lake (locally designated as "Everglades station" because of the fact that the barge *Everglades* is moored there); North New River Canal, at the lock; South New River Canal, at Zona; Miami Canal, 8 miles above Miami (locally designated as "Barkley's"). The increase of flow measured at these stations over that measured at the head of the canals would, it was originally believed, give the increment due to Everglades run-off. The results are given in Table No. 5.

TABLE No. 5.—*Flow of Everglade canals.*

[Cubic feet per second.]

Date.	North New River Canal at dredge Everglades.		North New River Canal at lock.		South New River Canal at Zona.		Miami Canal at Barkleys.	
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
1913.								
May 12							8.35	365
13			3.05	970	2.25	448	8.35	365
14			3.1	985	2.1	420	8.35	365
15			3.05	970	2.1	420	8.25	355
16			2.95	950	2.1	420	8.2	350
17			2.08	910	2.0	405	8.2	350
18			2.85	920	1.85	383	8.1	340
19			2.85	920	1.65	358	8.1	340
20			2.75	900	1.75	370	8.1	340
21			2.8	910	1.6	353	8.05	335
22			2.5	835	1.45	338	8.05	335
23			2.45	820	1.6	353	7.92	322
24			2.75	900	1.85	383	8.22	352
25			3.2	1,010	2.3	458	8.55	385
26			3.75	1,185	2.85	606	8.6	390
27			3.65	1,150	2.65	549	8.58	388
28			3.5	1,095	2.65	549	8.5	380
29			3.42	1,070	2.5	507	8.45	375
30			3.35	1,050	2.4	481	8.4	370
31			3.25	1,020	2.25	448	8.33	363
Total				18,570		8,249		7,165
Mean				977		434		358
Maximum				1,185		606		390
Minimum				820		338		322
June 1			3.3	1,035	2.15	429	8.26	356
2			3.28	1,030	2.0	405	8.22	352
3			3.25	1,020	2.1	420	8.43	373
4			3.08	980	1.95	398	8.63	393
5			3.05	970	1.95	398	8.73	403
6			3.18	1,005	2.1	420	8.81	411
7			3.15	1,000	2.0	405	8.73	403
8			3.25	1,020	2.15	429	8.75	405
9			3.68	1,160	3.0	650	8.85	415
10			3.8	1,205	3.25	722	8.83	413
11			3.92	1,255	3.3	737	8.8	410
12			3.92	1,355	3.35	752	8.81	411
13			4.05	1,305	3.4	766	8.85	415
14			4.02	1,295	3.46	780	8.8	410
15			3.98	1,280	3.4	766	8.78	408
16			3.88	1,240	3.3	737	8.73	403
17			3.78	1,200	3.3	737	8.7	400
18			3.72	1,175	3.15	694	8.65	395
19			3.58	1,130	3.0	650	8.7	400
20			3.48	1,100	3.0	650	8.83	413
21			3.4	1,065	3.0	650	8.85	415
22			3.35	1,050	2.95	636	8.86	416
23			3.25	1,020	2.9	621	9.05	435
24			3.30	1,035	2.98	644	9.15	445
25			3.35	1,050	3.1	679	9.13	443
26			3.40	1,065	3.15	694	9.17	447
27			3.40	1,065	3.2	708	9.25	445

TABLE No. 5.—*Flow of Everglade canals*—Continued.

[Cubic feet per second.]

Date.	North New River Canal at dredge Everglades.		North New River Canal at lock.		South New River Canal at Zona.		Miami Canal at Barkleys.	
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
1913.								
June 28			3.40	1,065	3.1	679	9.23	453
29			3.40	1,065	3.05	664	9.22	452
30			3.40	1,065	3.05	664	9.17	447
Total				33,205		18,584		12,397
Mean				1,110		619		413
Maximum				1,305		780		455
Minimum				970		398		352
July 1			3.6	1,130	3.05	664	9.12	442
2			3.5	1,095	2.95	636	9.03	433
3			3.42	1,070	2.85	606	8.92	422
4			3.32	1,040	2.65	550	8.9	420
5			3.32	1,040	2.6	535	8.92	422
6			3.22	1,015	2.7	563	9.02	432
7			3.45	1,080	2.8	592	9.2	430
8			3.35	1,050	2.7	563	9.23	453
9			3.1	985	2.8	592	9.3	460
10			3.1	985	2.7	563	9.23	453
11			3.1	985	2.65	550	9.2	430
12			3.0	960	2.5	507	9.15	445
13			3.0	960	2.4	481	9.13	443
14			2.95	950	2.35	470	9.07	437
15			2.9	935	2.3	458	9.18	448
16			2.9	935	2.25	448	9.15	445
17	2.5	552	2.82	915	2.45	494	9.1	440
18	2.5	552	2.75	900	2.5	507	9.05	436
19	2.4	542	2.72	890	2.5	507	9.03	433
20	2.4	542	2.7	885	2.1	420	9.02	432
21	2.4	542	2.68	880	1.9	390	8.95	425
22	2.4	542	2.62	865	1.9	390	8.9	420
23	2.4	542	2.55	850	1.85	383	8.83	413
24	2.4	542	2.5	835	1.8	376	8.82	412
25	2.45	547	2.42	815	1.65	358	8.78	408
26	2.4	542	2.32	795	1.45	338	8.7	400
27	2.4	542	2.28	785	1.55	348	8.65	395
28	2.4	542	2.22	775	1.45	338	8.6	390
29	2.35	537	2.25	780	1.4	334	8.52	382
30	2.3	532	2.4	810	1.4	334	8.5	380
31	2.3	532	2.45	825	1.3	325	8.42	372
Total		8,130		28,820		14,620		13,152
Mean		542		930		472		424
Maximum		552		1,130		664		460
Minimum		532		775		325		372
Aug. 1	2.3	530	2.45	825	1.3	325	8.40	370
2	2.25	527	2.45	825	1.38	333	8.37	367
3	2.2	522	2.75	900	1.85	383	8.4	370
4	2.2	522	2.85	920	1.9	390	8.4	370
5	2.2	522	2.7	885	1.9	390	8.4	370
6	2.15	517	2.95	950	1.9	390	8.4	370
7	2.3	532	3.18	1,005	2.2	438	8.5	380
8	2.3	532	3.15	1,000	2.3	458	8.5	380
9	2.25	527	3.1	985	2.25	448	8.45	375
10	2.2	522	3.0	960	2.1	420	8.4	370
11	2.2	522	2.9	935	2.0	405	8.37	367
12	2.2	522	2.78	905	1.9	390	8.33	363
13	2.1	512	2.65	870	1.85	383	8.25	355
14	2.1	512	2.65	870	1.85	383	8.23	353
15	2.1	512	2.8	840	2.0	405	8.2	350
16	2.1	512	3.05	900	2.1	420	8.37	367
17	2.2	522	3.12	920	2.15	429	8.77	407
18	2.3	532	3.05	900	2.3	458	8.87	417
19	2.3	532	3.1	915	2.35	470	8.85	415
20	2.28	530	3.05	900	2.3	458	8.8	410
21	2.25	525	3.08	910	2.3	458	8.75	405
22	2.58	560	3.1	915	2.65	549	9.02	420
23	2.58	560	3.22	945	2.7	563	9.07	420
24	2.55	557	3.3	965	2.6	535	9.05	423
25	2.62	564	3.3	965	2.5	507	9.08	427
26	2.65	567	3.2	940	2.45	494	9.02	420

TABLE No. 5.—*Flow of Everglade canals*—Continued.

[Cubic feet per second.]

Date.	North New River Canal at dredge Everglades.		North New River Canal at lock.		South New River Canal at Zona.		Miami Canal at Barkleys.	
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
1913.								
Aug. 27	2.62	564	3.2	940	2.4	481	8.97	415
28	2.6	562	3.2	940	2.3	458	8.88	406
29	2.58	560	3.2	940	2.25	448	8.8	398
30	2.56	558	3.1	915	2.1	420	8.78	396
31	2.52	554	3.0	890	2.2	438	8.72	390
Total	....	16,593	....	28,475	....	13,527	....	12,051
Mean	....	535	....	919	....	436	....	389
Maximum	....	567	....	1,005	....	563	....	427
Minimum	....	512	....	825	....	325	....	350
Sept. 1	2.522	530	3.0	890	2.15	429	8.63	381
2	2.5	552	2.9	865	2.05	412	8.6	378
3	2.49	551	2.85	850	1.95	398	8.57	375
4	2.45	547	2.78	835	2.0	405	8.6	378
5	2.44	546	2.8	840	1.95	398	8.57	375
6	2.44	546	2.8	840	2.1	420	8.78	396
7	2.49	551	3.0	890	2.15	429	8.98	416
8	2.52	554	3.05	900	2.25	448	8.95	413
9	2.5	552	3.12	920	2.3	458	8.9	408
10	2.48	550	3.0	890	2.15	429	8.83	401
11	2.48	550	3.12	920	2.0	405	8.75	393
12	2.5	552	3.25	950	2.35	470	8.80	398
13	2.5	552	3.4	990	2.8	592	8.93	411
14	2.54	556	3.42	995	2.8	592	9.1	428
15	2.5	552	3.3	965	2.7	563	9.03	421
16	2.5	552	3.3	965	2.6	535	9.12	430
17	2.48	550	3.4	990	2.6	535	9.13	431
18	2.49	551	3.38	985	2.5	507	9.07	425
19	2.48	550	3.28	960	2.48	502	9.03	421
20	2.5	552	3.3	965	2.4	481	9.0	418
21	2.5	552	3.32	970	2.45	494	8.98	416
22	2.52	554	3.4	990	2.65	549	8.98	416
23	2.5	552	3.4	990	2.55	521	8.9	408
24	2.46	548	3.6	1,045	2.75	578	8.92	410
25	2.5	552	3.68	1,075	2.9	621	9.0	418
26	2.49	551	3.68	1,075	2.75	578	8.97	415
27	2.42	544	3.62	1,050	2.65	549	8.9	408
28	2.41	543	3.50	1,015	2.55	521	8.88	406
29	2.35	537	3.35	980	2.45	494	8.8	398
30	2.35	537	3.25	950	2.3	458	8.8	398
Total	....	16,490	....	29,425	....	14,771	....	12,190
Mean	....	550	....	981	....	492	....	406
Maximum	....	554	....	1,075	....	621	....	431
Minimum	....	537	....	835	....	398	....	375

Several points of uncertainty should be recognized in connection with the results in Table 5. There has been at all times during the period of investigation a considerable flow from the surface of the Glades into the North Canal and out of the North across to the South Canal. Whether or not all of this water may be truly accounted as Glades drainage is questionable because a part of it may be surface water from the overflow of the Hillsborough Canal.

Conclusions relative to such run-off can not be derived from the South New River Canal and from the Miami Canal records because of the uncertainty concerning the area to the westward. It is apparent that the "western edge of the Everglades" is an imaginary line so far as drainage direction is concerned. Therefore, we are unable to assume any reliable watershed factor with which to compute unit run-off.

In the North Canal, conditions should be more favorable, inasmuch as we may safely assume that the watershed limits extend approximately halfway to the Hillsborough Canal on the one side and to the Miami and South New River Canals on the other. The figures in Table 5 indicate the following:

Drainage area between Lake Okeechobee and dredge *Everglade*, 102 square miles; between dredge *Everglade* and lock, 227 square miles.

Mean flow in cubic feet per second.

	May.	June.	July.	August.	September.
Head of canal	608	561	497	443	419
Dredge Everglades			542	535	550
Difference			45	92	131
Difference per square mile			0.44	0.90	1.28
Dredge Everglades			542	535	550
Lock	977	1,110	930	919	981
Difference			388	384	431
Difference per square mile			1.49	1.49	1.9
Head of canal	608	561	497	443	419
Lock	977	1,110	930	919	981
Difference	369	549	433	476	562
Difference per square mile	1.12	1.67	1.31	1.44	1.71

The foregoing data are not especially significant. While they show a certain increment of flow between the stations named, the condition is abnormal. The canal was practically bank full the entire period, because of the influx of Lake Okeechobee water. It is unquestionable that the Everglades contribution would have been considerably greater had there been any space in the canal into which local drainage water could go.

Southern Louisiana run-off.—Having for reasons above discussed failed to secure flood run-off data in the Everglades, it becomes necessary to use the run-off results observed on a selected area, which compares as closely as possible in physical conditions with the Everglades, as a basis of estimate. Hydrometric work in regions of this character appears to have been generally neglected. It happens, however, that since July, 1909, intensive studies have been maintained by the Office of Drainage Investigations, United States Department of Agriculture, in cooperation with certain plantations in southern Louisiana. The results, which consist of observations of rainfall and run-off, have been compiled to December 31, 1912, and distributed in mimeograph form by that office. They have been used in part for the deductions made in this report.

The only series directly applicable is that made on the tract of the New Orleans Land Co., 1,080 acres in extent, lying within the northern city limits of New Orleans and fronting on Lake Pontchartrain. The outfall from this tract is by way of the New Basin Canal, which borders it on one side. City pumping station No. 7 is located close by and by pump operation the water level of this canal has, during the entire course of the investigation, been kept well below the level of the New Orleans Land Co.'s tract. The run-off measurements have been made over a sharp-crested weir and the head of water over the weir crest has been recorded by an automatic gauge. This arrangement affords a constant record of the discharge from the tract.

The records on other tracts in southern Louisiana, though valuable in general work, do not furnish a continuous history of actual run-off. On those plantations the drainage water is artificially elevated from the canal basins by pumps. These pumps are not started until the water in the basins rises, after storms, to a certain height and operation is discontinued when the water level is again lowered below that point. While these records show the amount of water necessarily removed to maintain a soil sufficiently dry for agricultural operations, they do not constitute a record of actual run-off. They are rather a record of necessary pump operation. The tables show that there are, in some dry seasons, periods of one month or more in which no pumping is necessary. It is clear that during those months some small amount of run-off would, under natural conditions, be derived from these plantations. Moreover, there is no record of the speed with which the water entered the pumping basins from the canals. Pump discharge need not, and undoubtedly does not, conform in rate to that at which the water is contributed to the basin from the land. Therefore, though the records from these plantations are useful in determinations of total run-off, they are quite valueless in all comparative computations in which the time element is an important factor. For this reason only the records secured on the tract of the New Orleans Land Co. are valuable for this investigation.

Consideration will be given only to those periods of record in which heavy rainfall has occurred. The important periods are given in the following table:

Date.	Rainfall.	Run-off.	Date.	Rainfall.	Run-off.	Date.	Rainfall.	Run-off.
1909.	*Inches.*	*Inches.*	1910.	*Inches.*	*Inches.*	1911.	*Inches.*	*Inches.*
June 19	0.00	0.007	May 19	2.83	0.079	Apr. 28	0.00	0.73
20	.23	.013	20	.00	.058			
21	1.26	.023	21	.27	.065	1912.		
22	.00	.029	22	1.57	.082	Mar. 20	.00	.09
23	.00	.028	23	1.25	.114	21	.05	.08
24	1.35	.048	24	.30	.138	22	3.60	.24
25	.00	.057	25	.00	.116	23	2.40	1.09
26	.00	.059	Aug. 25	.00	.035	24	.00	1.78
Oct. 18	.00	.035	26	2.85	.146	25	.00	.84
19	.91	.066	27	.22	.131	Apr. 9	.00	.06
20	1.17	.143	28	.00	.001	10	.15	.06
21	.11	.128				11	.26	.07
22	.00	.102	1911.			12	1.39	.07
Dec. 11	.00	.059	Apr. 7	.00	.08	13	.21	.17
12	2.74	.120	8	4.03	.69	14	2.10	.71
13	.00	.337	9	.00	.98	15	.00	1.42
14	.80	.331	10	.00	.47	16	1.60	1.08
15	.00	.320	Mar. 21	.00	.015	17	.00	.69
			22	3.80	.336	Dec. 2	.00	.03
1910.			23	.00	.623	3	.25	.04
Mar. 9	.00	.053	24	.00	.374	4	.90	.04
10	3.11	.096	Apr. 23	.00	.11	5	1.00	.05
11	.00	.184	24	1.05	.11	6	3.00	.20
12	.00	.50	25	.00	.11	7	.00	1.36
May 17	.00	.000	26	2.72	.58	8	.00	.45
18	.00	.025	27	.50	.81			

The foregoing table records nearly all the heavy storms which produced a high run-off during the period June, 1909, to December, 1912, inclusive. It will be noted that the record in each case is discontinued shortly after the beginning of recedence of run-off. A general perusal of the figures shows the usually observed condition, viz, that a small amount of rain on a well-saturated ground will produce a higher run-off than a larger amount of rain on a ground less saturated. Note, for example, that the 2.74-inch rain on December 12, 1909, fell when the run-off on the previous day was 0.059. The flood wave on the day following this rain represented 0.337. On May 19, 1910, a rainfall of 2.83 on a ground discharging 0.025 produced a run-off of only 0.079. On the other hand, comparison of the storms of December, 1909, and March, 1910, shows that in the latter case the much higher rainfall on a ground apparently nearly as well saturated as in the former does not produce as high a run-off. Therefore it is apparent that many physical conditions other than soil saturation influence the ratio of rainfall to run-off. Of course one of the most important of these conditions is intensity of rainfall. Many similar and instructive circumstances may be discovered in the table.

We are particularly interested in the three highest rates of run-off, viz, March 24, 1912—1.78 inches, April 15, 1912—1.42 inches, and December 7, 1912—1.36 inches. The first two came during a period of unusually copious rainfall, when the entire lower Mississippi Valley was in the midst of an historically violent flood. During the previous December, January, and February the rainfall had been 4.43, 4.48, and 3.70 inches, respectively, while the fall in March previous to the 22d had been 3.27 inches. The soil probably held its maximum amount of capillary water and was, at the outset of the March storm, yielding surplus drainage water to the canal system at the rate of 0.08 inch per day. Six inches of rain fell on March 22 and 23. By dividing the depth by the number of days duration we derive a factor which we will call rainfall intensity. This gives an intensity of 3, producing a run-off of 1.78 inches.

The second heavy storm took place April 12–14, 1912. The same generally wet conditions continued up to the beginning of this storm, the ground held its maximum capillary water and was yielding drainage water in the amount of 0.07 inch per day. From the 12th to the 14th there fell 3.70 inches of rain. We, therefore, have an intensity of 1.25 producing a run-off of 1.42. From December 4–6, 1912, there fell 4.9 inches. The intensity is, therefore, 1.63 and the run-off 1.36 inches per day. This storm took place after three months of rather low rainfall, viz, September, 2.88; October, 1.72; and November, 2.17 inches. On the 1st and 3d of December there fell a total of 0.88 inch. The drainage water yielded by the land to the canals at the beginning of the storm was 0.04 inch per day, or only one-half that which preceded the storm previously discussed. This fact explains in large part the higher intensity factor and lower run-off than those in the April storm.

Summarizing the foregoing we have:

Storm.	Intensity.	Run-off.
1912.		*Inches.*
March	3	1.78
April	1.25	1.42
December	1.63	1.36

EVERGLADES RUN-OFF.

The task now remains to apply these results to the Everglades. Before doing so we must consider and make all possible allowance for the difference in physical conditions in the two places. Land surface grades are practically the same. The Louisiana country is probably somewhat more flat than the Everglades, though the latter has so little grade that it is negligible in these particular considerations. The two places have comates so nearly alike that the difference can not be accounted for in comparing rates of percolation. We have therefore to appraise the muck cover in the two places.

The soil cover on the New Orleans Land Co.'s tract is principally a "tree muck." The upper foot is of fine loose texture, mixed with a considerable portion of roots and fibers. The second foot is similar to the first except that the fibers and roots form a greater portion and the earth contains numerous passages, both vertical and horizontal, which are caused by root decay and by the burrowings of crayfish and mice. Below this is a stratum 3 or 4 inches thick, consisting principally of roots and fibers, with very little soil or muck. Finally there is a stratum of mixed clay and silt through which the rate of percolation is extremely low. These observations, which were made and reported to the commission by Mr. John L. Porter, director New Orleans water filtration plant, were not carried below the clay stratum because, as will be shown below, the purposes of the inquiry were satisfied by the upper 3 feet. It will readily be seen that practically all of the drainage water is discharged from this tract into the canals over the top of the fine clay layer, the root and fiber stratum especially furnishing a ready lateral exit over the whole tract.

Soil cover on the Everglades is a "grass muck," overlying rock in some places and marl at others. In texture it is coarsely fibrous. Over the greater part of the 'Glades it is over 5 feet in thickness, reaching in some places to 12 or 13 feet. To the south the muck thins out and in some places is less than 2 feet deep. As a result of the proposed canalization the water table may be lowered to an average depth of about 3 feet. Heretofore the rate of percolation to be considered concerns only that of the muck.

In order to compare the relative porosity of the soil in the two places, experimental boxes were constructed by Mr. Porter in New Orleans, into which both kinds of muck were placed to a depth of 3 feet. Every precaution was taken to preserve the stratigraphy of the muck and to place it in the boxes at about the same degree of compaction as existed in the natural conditions. The only artificial compaction given to the muck in either case was that occasioned by the shaking which the boxes received in transit on wagons. A screen was placed in the bottom of the box, and this, together with 0.5 inch of gravel and a like thickness of sand supported the overlying muck. An artificial water table 2.5 feet from the surface was created by setting the filters in tight boxes, filled with water to a point of overflow corresponding with the desired height of water table. Overflow outlets were placed in the filters at the muck surface elevation, and water was allowed to flow over the surface at a rate sufficient to run slowly from these overflows. This insured a supply of water quite constant in amount and always sufficient to supply the maximum percolation demanded.

The operation of the two filters showed maximum rates of percolation as follows: New Orleans, 0.9 foot per hour; Everglades, 4.5 feet per hour. It should here be emphasized that the actual rates shown have no significance. The point to be remembered is that under conditions as nearly uniform as can be made the rate of percolation through Everglades muck, as evidenced by the experiments described, is five times that through New Orleans muck. Thus inferentially, Everglades muck, under good drainage conditions, offers little resistance to the passage of the rain from the soil surface to the canals. The Louisiana storm of March 22–23, 1912, certainly would have produced a daily run-off of 3 inches on the Everglades muck had the capacities of the drainage canals been sufficient to carry that amount, and the muck would not, even then, have been taxed to its utmost capacity.

In view of this discussion of Everglades muck, the question will naturally arise in considering the plans presented by this commission—what good purpose will be accomplished by the construction of locks on the now existing canals and those in the process of construction or under contract? Will not the water flow freely around these locks? Though porous, as our experiments show, water does not flow as freely through this muck as it does in an open channel. This is shown by the lock on the North Canal; at this canal there is a wide channel around the east side of the lock through which there is a rapid flow of water and yet there is a decided difference in elevation of water between the upstream and downstream end of the lock; all of the usual operations of closing valves in the upstream and downstream gates of the lock have to be performed before those gates will function in proper sequence.

In a newly dug channel the outflow into adjacent muck lands will be greater in its early use than it will be later after the porosity of its sides and bottom has been diminished by silting up almost to the extent of imperviousness. Lake Okeechobee itself is an illustration of the manner in which this sealing of sides and bottom by unfiltered silt has taken place and left it a reservoir; its shores are no longer sieves since silting up has made them retentive.

Having established this general relation, it now becomes necessary to appraise storm rainfall in the Everglades.

Review of the daily rainfall records during the 14 years from 1899 to 1912, inclusive, at the stations in and surrounding the Everglades shows that the average daily rainfall, as measured at the several stations at the time in operation, may be classified as follows:

In excess of—	Days.
2.0 inches	12
1.9 inches	16
1.8 inches	23
1.7 inches	24
1.6 inches	27
1.5 inches	35
1.4 inches	41
1.3 inches	46
1.2 inches	50
1.1 inches	59
1.0 inches	69
0.9 inch	98
0.8 inch	128
0.7 inch	171
0.6 inch	234
0.5 inch	322

The determination of the proper capacity of any drainage system is finally a matter of economics. Storms and consequent run-off vary greatly in amount and intensity. Very great storms are comparatively rare; moderate storms are common; small storms usually occur several times each month. To provide a drainage system sufficient to carry, without overflow, the largest storms would require canals of enormous capacity. Their cost, including maintenance, and the great aggregate area which they occupy, which area is, of course, made forever unavailable for agricultural operations, would undoubtedly render the Everglades project impracticable. The question is, therefore, one of dollars and cents. The damage caused by overflows that may occur only once or twice in a year aggregates, in flat country, only a small part of the cost of providing channels large enough to carry those floods. It is a well-established fact that agricultural land is not damaged by occasional overflows if the water does not remain long upon the surface and if the drainage outlets are of sufficient capacity to reduce within a reasonable time the moisture in the soil to a degree favorable for crop growth.

Indeed, many lands are benefited by these overflows. Unless the overflows be too deep or descend with violence, the principal damage is that of temporary inconvenience. Practically every great agricultural region in the humid parts of the United States occupies relatively flat country, subject now and then to overflow. Even in rolling country, the lower lands, usually considered the most valuable for agriculture, have their occasional inundations. Therefore, according to standards that prevail almost universally, a drainage system is not considered inadequate if it fails to carry the largest floods. In the Everglades violent floods are inconceivable; the very flatness of the country and the absence of tributary uplands of high slope makes it certain that overflows occur by the quiet and gradual rise of water, without torrential characteristics. The farmer on the Everglades will instinctively take all of these things into account. His houses, barns, and all structures and equipment subject to more or less damage by water will be raised above and diked off from the temporary overflow of a few inches depth. In the case of houses and stables the requirement is a good one for hygienic reasons alone, even if no overflows occur. Roads and highways would, under intelligent administration, be raised above the general level in any event. Therefore, even during temporary overflows the farmers' means of egress would not be cut off.

In addition to the foregoing considerations there is the fundamental question of overdrainage. A certain amount of moisture must be retained in the soil. It is readily apparent that even under a perfectly adapted drainage system irrigation must be practiced in the Everglades. The high porosity of the soil, the long dry periods, and the plenteous water demands of the crops that are apparently the most profitable in this region, all portend a great irrigation necessity. For these and for many other familiar reasons overdrainage would be fatal. It therefore appears that a drainage system that is too small to carry the highest floods is not only desirable from the financial standpoint, but necessary for agricultural reasons.

In determining upon the best canal capacity, it should be noted that the foregoing figures as to the depth of storms are made up of averages of all observations at the rainfall measurement stations. They hold true for the Everglades as a whole, but it is known that at particular points during each storm the precipitation is much greater than the average. Local catchment in excess of 9 inches per day has been observed. Clearly a drainage system designed to carry the average of, say, 0.6 inches would be inadequate for the area over which the 9-inch storm fell. We know, however, from intensive observations made elsewhere that areas of enormous rainfall occupy narrow limits. It has been observed that great differences in precipitation may occur even at points less than 1,000 feet apart. Here in Florida the records at Clermont, Kissimmee, and Orlando reveal extreme differences in storm catchment, notwithstanding the fact that these places are located in the same general region. These areas of high local precipitation do nevertheless enter into the problem. They raise canal capacity requirements above those which might be considered satisfactory if the maximum catchment did not exceed the average.

Considering all of the foregoing, in connection with the tabulated statement of storm depth and distribution, the commission believes that local drainage capacity equivalent to a depth on the surface of 0.6 inch per day is best suited to the demands and financial considerations. As has already been stated this decision is subject to confirmation by subsequent intensive hydrometric studies, without which no hard and fast conclusions can ever be drawn. This is equivalent to a discharge of 16 cubic feet per second per square mile. This applies to each individual square mile. Of course, by reason of time and distance elements the necessary capacity of the larger canals will be less.

In arriving at this decision that canal capacities must be equivalent to a run-off of 0.6 inch per day, the commission wishes again to emphasize its previous declaration concerning final acceptance of the premises used. It can not in truth and does not in fact guarantee the absolute accuracy of the run-off findings. Nevertheless, the commission has sufficient confidence in them to advise immediate procedure with the plans here proposed.

The figure 0.6 inch per day is essentially derived from two premises: (1) That the Everglades muck is shown by experiment to possess five times the rate of percolation that is shown in the New Orleans muck. From the run-off ratings actually observed in the latter it is manifest that the former should in times of heavy rain deliver run-off equivalent to 3 or 4 inches per day; (2) that, in our judgment, based on financial and agricultural considerations, the Everglades must sustain occasional overflows of short duration, in common with agricultural lands in other regions, both naturally and artificially drained; further, that the rainfall records show that during the past 14 years there have been 234 storms averaging in excess of 0.6 inch per day or about 17 per year, and that this does not take account of the more intense and deep precipitation that prevails over limited areas and which for the time being requires more drainage capacity than that represented by the average.

Now, it may possibly be proved by subsequent observation that the percolation rate shown by experimentation will for various and sundry reasons not persist under natural conditions. We believe that it will, but admit the possibility that the actual figure may be less. Against this possible discrepancy, however, and to compensate any errors involved thereby, we place our allowance of 14 overflow storms per year. This does not necessarily mean that the days of actual overflow resulting from these storms will be limited to 14. Under severe storm conditions the overflow periods might aggregate

30 days or even more, though not in one consecutive stretch. This we believe to be an over-liberal allowance, or in other words somewhat more overflow than the lands should, under ideal conditions, be called on to sustain.

Therefore, if there be any complaint of over-liberality in our percolation factor in the one direction, let the complainant contemplate our over-liberality as to flood sufferance in other direction. We are all persuaded by the weight of evidence as it meets our several interpretations. In the present case the basis for hard and fast conclusions does not exist. The real question is not whether our percolation factor is too high, or our flood sufferance factor is too liberal, but whether, all things being considered, our ultimate capacity factor of 0.6 inches is justified. We believe that, under present state of knowledge, it is.

CONTROL OF LAKE OKEECHOBEE.

The contract of April 30 last, under which we are proceeding, calls for investigations, conclusions, and estimates of cost within the existing drainage district. Since that date the legislature has extended the boundaries of the district, but the change does not materially alter the area to be considered nor require any greater research on our part. At the conference between your honorable body and our chairman, on September 2, you requested that we consider the effect of the proposed lowering of the lake upon the problem of draining the lands in the Kissimmee Valley and give expression to our views relating thereto.

In our judgment the major element in the reclamation of the lands south of Lake Okeechobee is the prevention of their overflow by the flood waters sent down from the Kissimmee watershed. Also, in our judgment, the successful reclamation of a large portion of the lands in the Kissimmee Valley is dependent upon the lowering of the lake, as contemplated in the present project. We believe that the logical way to control the lake is by the excavation of a canal of suitable size to the nearest ocean outlet, and such canal should be excavated along a course where local drainage problems are at a minimum. From so vast a problem of lake control and operation every conflicting detail should be eliminated or simplified. An outlet canal designed solely or primarily for lake control surely presents operation difficulties enough; such difficulties should not be multiplied by distributing them among many canals or by complicating them with local drainage. There is here suggested two types of canal; the first for the discharge of lake water and the control of lake levels, in which local land drainage is merely incidental; the second solely or primarily for agricultural land drainage, in which the discharge of lake water is either limited or is dictated by the urgency of a great flood.

The boundaries of the Everglades drainage district are located arbitrarily. Men may establish and extend lines as suits their fancy, but they can not by so doing change any natural laws or fundamental necessities. Such laws and necessities were established in the area tributary to Lake Okeechobee many thousand years before man conceived such things as boundary lines. Though the northern limit of the drainage district is set between township 36 and 37 south, the necessities of all the land lying to the north still remain. The improvement afforded by the control of Lake Okeechobee and the lowering of its surface can not be confined to the legally established district boundaries. Unless man intervenes to prevent, all of the country in the basins of Kissimmee River and Taylor's and Fish-eating Creeks will be greatly benefited. Moreover, it would be practically impossible to suitably drain these basins without the contemplated improvement in Lake Okeechobee. Even under present conditions, Kissimmee River in time of flood overflows wide areas of country. Drainage of swamp lands means quicker run-off. Therefore drainage can not be accomplished in this valley unless a greater slope and a greater velocity is given to Kissimmee River. Logically the mouth of the river must be lowered, and this is precisely what will be accomplished.

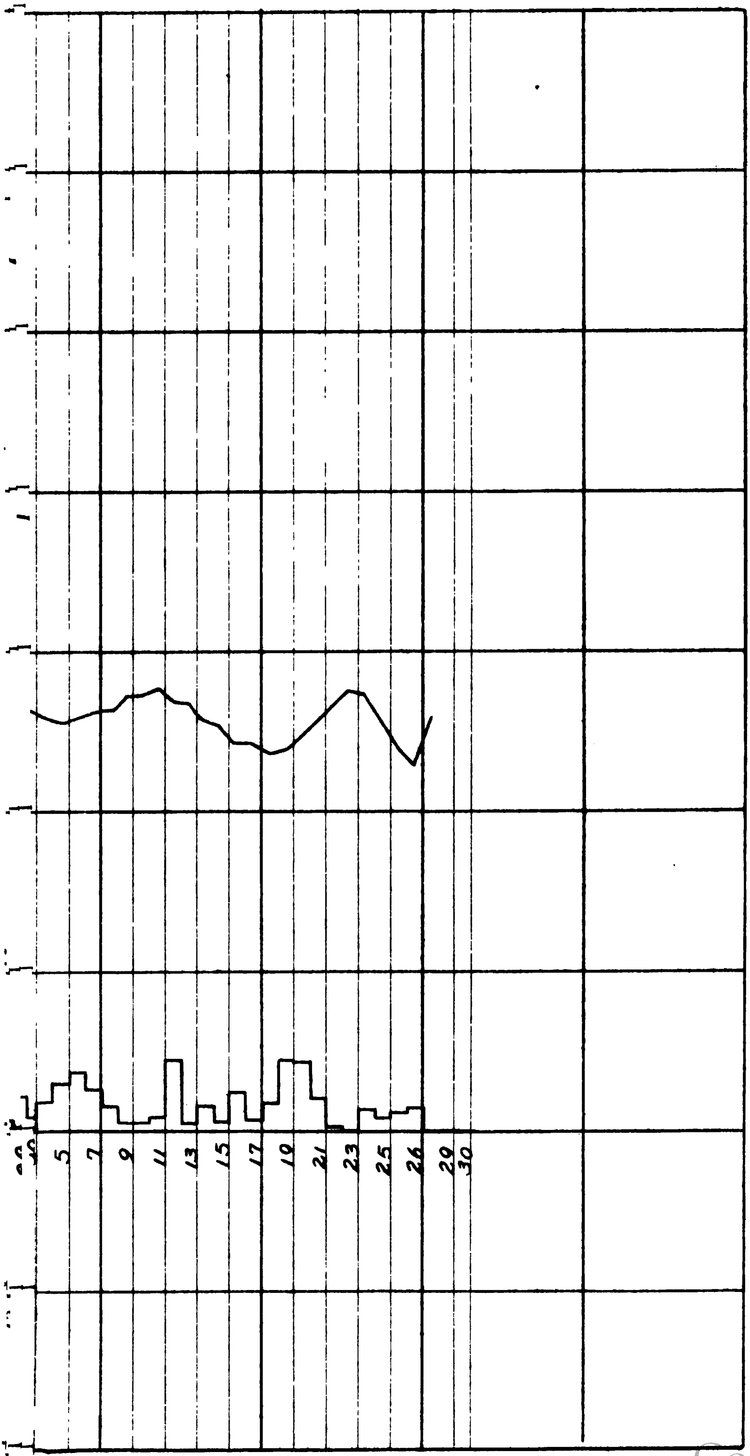
Whenever a city constructs a sewerage system, it builds large outlets to carry the combined flow of all the lateral sewers. These large outlets must be paid for, even as are the laterals. No city ever proposed to tax the owners of property lying along the course of the outlet sewers and leave free from taxation those owners of similar property which happened to lie along the lateral sewers. Such a proposition would be justly condemned and would be promptly reversed by the courts. Each property owner within any city limits is expected to pay his just share for sewer-outlet benefits. This principle is so familiar that no argument is required in its support.

Upon Everglades property the present State plan proposes to place the burden of the outlet sewer and leave free from obligations the beneficiaries in the country to the north and west. The commission therefore declares that the property beyond the district borders tributary to the lake should bear its just outlet-cost burdens; that so far as these outlet costs are concerned the legislature should pass suitable laws extending the district boundaries to the marginal limits of the three streams above mentioned, so that these just burdens may be legally imposed. And with equal emphasis we call attention to the fact that the progressive drainage of these lands benefits the entire acreage of the district even though the immediate effect upon the more remote areas is not physically visible.

We have been furnished with a copy of House Document No. 137, Sixty-third Congress, first session, the same being a report on the improvement of the Kissimmee and Caloosahatchee Rivers for navigation. A 3-foot navigation is recommended for the Kissimmee River, to be obtained at a cost of $37,000 and an annual charge of $6,000 for maintenance. On page 29 occurs the following:

> "If the State's drainage operations are successful and the level of the lake (Okeechobee) is lowered as contemplated, the State should be required to construct at its own expense a lock and dam at the mouth of the Kissimmee River and to dredge at its own expense a channel from this lock to the 6-foot curve in the lake. The height of the spillway of the dam should be placed at about elevation 22. At high-water stages the water would flow around the ends of the lock and dam, but this would have no great effect upon navigation, as the function of the dam is merely to hold up the surface of the water in the lower river to the same elevation as now exists during low-water stages in the lake."

Should Congress adopt this recommendation, the Kissimmee Valley would be barred from realizing any benefit from the lowering of Lake Okeechobee, and the cost to the State of Florida of maintaining the paltry navigation that would be possible in such a channel would not merely consist of the cost of the lock and dam and the channel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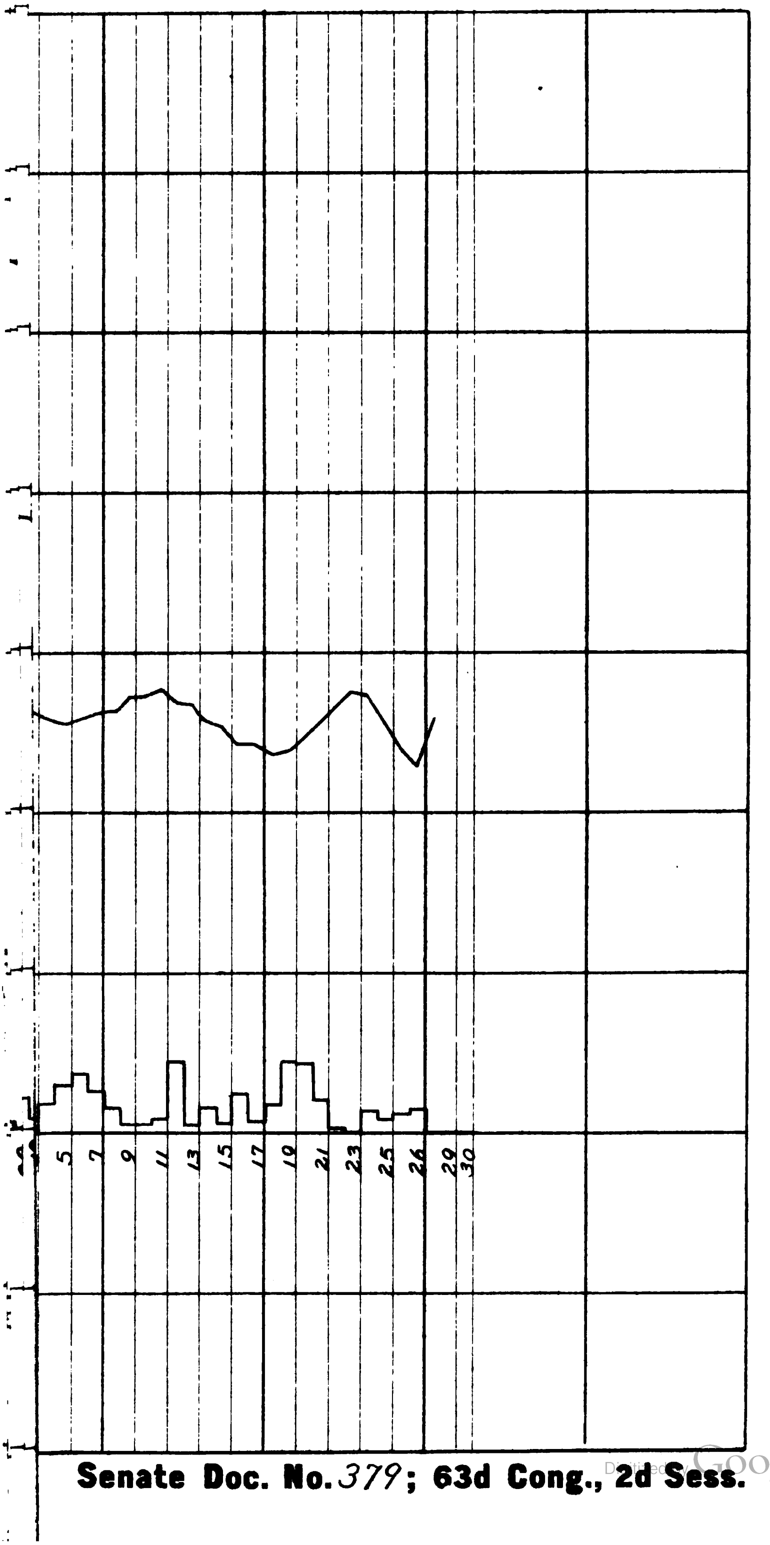
improvements mentioned in the report of the engineer officers, but it would be equivalent to the value of more than 1,000,000 acres of the richest lands within Florida borders, because they would thus be condemned to remain swamp lands, producing little except reptiles and miasma, whereas they should, under reclamation, have a selling value of at least $100,000,000. A 3-foot waterway for navigation is certainly not worth this price.

LAKE OKEECHOBEE RUN-OFF.

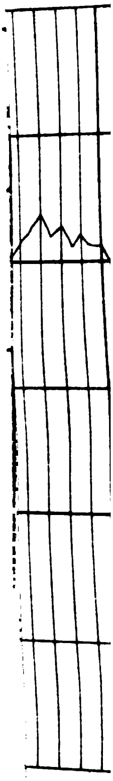
Plans for the control of Lake Okeechobee necessitate as accurate knowledge of run-off from the contributing area as do plans for local drainage in the Everglades. In the former case, however, we are fortunately possessed of fairly accurate information, according to which certain well-attested conclusions may be drawn. Since March 13, 1912, lake levels have been observed at Observation Island by or under the direction of Dr. L. K. Armstrong. Rainfall records in and surrounding the Everglades are available, as has previously been explained. Finally, a lake survey, mentioned in another section of this report, affords the remaining necessary information. This lake survey, with its accurately established contours at elevations 16 and 20 above tide, affords information as to the capacity of the lake between these two levels; and by reason of the uniformity of land slopes above elevation 20 the same capacity factors may, without appreciable error, be applied to this portion up to the point of overflow. The record of lake levels furnishes the factor for determining the volume of inflow or outflow at any time, and the rainfall records demonstrate the underlying cause of lake fluctuations.

Rainfall and lake levels are represented graphically by the accompanying diagram entitled "Record of rainfall in region tributary to Lake Okeechobee and of levels of lake, January 1, 1912–September 30, 1913." The rainfall records are the means of recorded observations at Clermont, Kissimmee, Orlando, Malabar, Fort Pierce, Fort Meade, Bartow, Arcadia, Avon Park, Okeechobee, Observation Island, Ritta, and Head North Canal. The original records of lake level have been modified to compensate for wind effects. Water elevation at any given point in the lake is greatly influenced by velocity and direction of wind. Ordinary daily fluctuations vary from 0.1 to 0.2 foot. The changes of true level in a lake so large as this must, except during a very violent flood, be very slow. Nevertheless, recorded daily variations at Observation Island of 0.3 foot are not uncommon. If this were the true variation it would represent an increase or a decrease of 6,000,000,000 cubic feet. This, in the absence of any well-defined cause, is of course preposterous and must be almost wholly due to wind action. To eliminate in a broad way this element and to give to the record an appearance in keeping with the unquestionable facts the records have been expressed as "progressive averages," i. e., each day's record on the diagram is the mean of that day, the two previous, and the two succeeding days.

The diagram largely relates its own story. Attention is called to two important points. (1) From June 6–11, 1912, rain fell to a depth of 8.04 inches. This occasioned one of the most rapid and extensive lake rises within the memory of those familiar with the region. The maximum level attained was 21.7 feet. Did this storm cause the lake to overflow? If not, it furnishes an acceptable basis for calculation of run-off and storage.



Senate Doc. No. 379**; 63d Cong., 2d Sess.**



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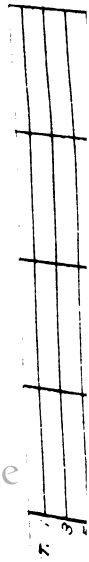

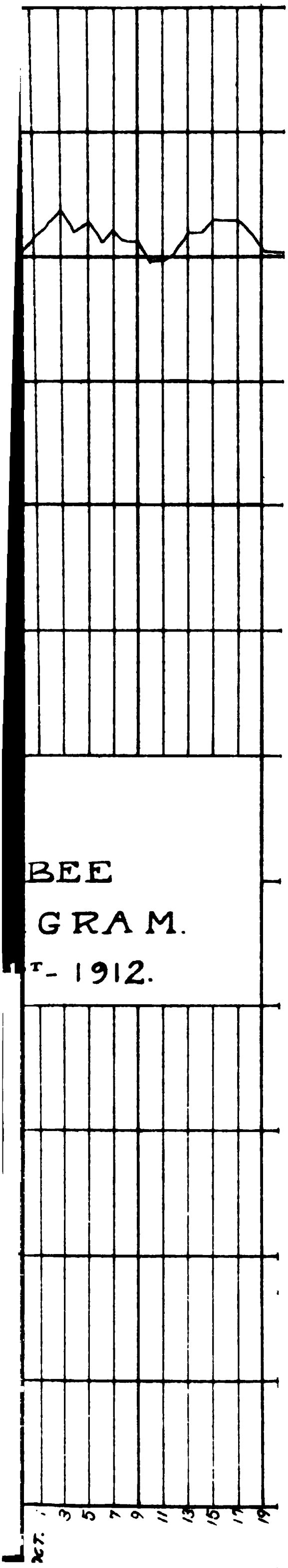
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Attention is invited to that part of the lake stage curve lying between July 15 and November 9, 1912. It will be noted that relatively wide variations in level are indicated, the maximum range being 0.3 foot, equivalent to 6,000,000,000 cubic feet of water. The lowest part of the lake rim along the southwestern border from Ritta to Threemile Canal is approximately 25 miles long. If we neglect, for the moment, all other low portions and outlets we have here alone a spillway 132,000 feet long. An average depth over this spillway of 0.1 foot moving at the rate of only 2 feet per second represents a discharge 26,400 cubic feet per second, or about 2,280,000,000 cubic feet per day. Examination of the rainfall diagram for this period shows that after the great storm of June, 1912, no precipitation occurred in volume sufficient to cause anything like these daily fluctuations, and in addition to supply the enormous volume of overflow water indicated. The whole aspect of the curve is such as to justify the assumption that these variations in level are caused by an inflow from storms into a basin which possesses a well-defined capacity and not into one whose level is regulated by a spillway 25 miles long. Of course there was some outflow through the Threemile and North New River Canals and probably through certain unfinished canals and natural channels. But a moment's consideration of the capacities of these canals and a reasonable allowance for other means of egress shows that the aggregate capacity must be so low in comparison with the enormous storage quantities involved as to affect the problem in only a negligible way.

We are further assured in our assumption that the lake did not overflow broadly by the testimony of reputable parties who were on the ground. Certain engineers who were in the Everglades to the south of the lake, in a locality that would surely have been submerged by such overflow, state positively that none occurred.

The second point of especial interest in this diagram is the establishment of the fact that it requires a very great storm to produce any substantial and long-standing rise in the lake. Note that during the periods March 17–May 3, 1912, and January 1–September 30, 1913, the lake level had a decided downward trend, and this in spite of the fact that during these periods the rainfall was at times quite pronounced. The circumstance affords a great factor of flood storage safety, inasmuch as, in the operation of the lake as a reservoir, only the great storm periods must be considered in avoiding lake overflow.

Attention is now invited to the diagram entitled "Lake Okeechobee Storage, Diagram June 1–December 31, 1912." On this sheet the lake levels have been converted into their equivalents in terms of billion cubic feet of storage and the datum has been lowered to elevation 16 above tide. The diagram indicates what would have taken place in the lake had the storm occurred under the improved conditions, with the lake level drawn down to 16 at the time of storm onset. It will be seen that the maximum storage from the great rainfall of June, 1912, together with the run-off from the rains of less magnitude which followed it, amounts to 53,000,000,000 cubic feet and would have raised the lake level to only 18.8. Above this, to the point of overflow, there is a storage capacity of about 3 feet, which is equivalent to approximately 60,000,000,000 feet of storage, or an excess capacity greater than that required for the entire storage of the run-off from this storm. In other words, had the lake been at level 16 when this storm started and had the storm produced twice the run-off that actually occurred, the lake would have had sufficient capacity to store it all without great overflow.

There have been no storms within the period of record of anything like twice the depth of that of June, 1912. In fact only one storm within the record was greater—viz, that of October, 1910. The October storm was only 1.65 inches deeper than that of June, 1912. While we have no record of the behavior of the lake at that time, the local testimony merely indicating that it overflowed broadly, no argument is needed to establish the assurance that under the conditions of lake regulation recommended in this report, the lake basin would have stored all the run-off water and have had ample capacity to spare.

From the foregoing it appears that a provisional plan for lake maintenance recommends itself as follows: Let the minimum lake level be established at 16 feet above tide; let the maximum working level be elevation 19; let the lake capacity between 19 and the point of overflow—say 21.5—be held for emergency storm storage. If it should ever happen that with the lake at elevation 19 a storm equivalent to that of June, 1912, occurs there will yet be sufficient capacity up to the point of overflow to store nearly all of the run-off water. It seems well-nigh impossible, however, that such a storm ever will occur when the lake is at elevation 19. The rainfall records show that two great storms have never occurred in one year, and inasmuch as it will require a great storm to raise the elevation to 19 in the first instance, a second one of like intensity is hardly to be expected. Therefore it will be entirely safe to use the St. Lucie outlet canal to the extent of the normal daily requirements for water power and navigation and the other drainage canals for the incidental irrigation and navigation up to the time that the lake rises to elevation 19. Then the St. Lucie outlet should be opened to full capacity and maintained thereat until the storm season has passed. If the capacity of that proves to be insufficient to prevent the lake from rising too rapidly above that elevation the locks of the great drainage canals leading from the lake can be opened. This schedule promises entire safety and at present writing appears fully practicable. Subsequent experience will probably indicate another scheme of control, but the change can hardly be sufficiently radical to affect the broad conclusions here stated.

Records of rainfall since 1899 indicate a distribution of storms that will make it possible to arrange in advance a schedule of lake operation that will rarely if ever be violated. In the 14 years from 1899 to 1912, inclusive, the high monthly rainfalls have been distributed over the year as indicated below:

Month.	Monthly rainfall in excess of—			
	10 inches.	9 inches.	8 inches.	7 inches.
January	0	0	0	0
February	0	0	0	1
March	0	0	0	0
April	0	0	0	0
May	0	0	0	2
June	2	3	6	8
July	0	1	2	7
August	3	4	8	8
September	2	4	5	6
October	2	2	2	6
November	0	0	0	0
December	0	0	1	1

It will be seen from the foregoing that all the extremely heavy monthly rates of rainfall above 8 inches have, with one exception, occurred between May 1 and October 31 of each year, while monthly rain in excess of 7 inches has occurred in only four cases outside of this period. This is, therefore, the season of water storage during which it may be expected that the heavy lake-filling rains may come. The lake should always be drawn down to approximately its minimum level (16) in May. On or about June 1 it will be advisable to commence to save all the water possible and continue up to the time that the lake level reaches elevation 19. Probably during the majority of years the lake will not reach that point. After November 1 there is only a remote possibility that heavy storms will occur.

The St. Lucie outlet canal has been planned to a capacity of 5,000 cubic feet per second at elevation 16, and 7,000 cubic feet per second at elevation 19. At the latter elevation the present 3-Mile, Miami, and North New River Canals have a discharge capacity of 1,350 cubic feet per second. The 9-Mile Canal carries no perceptible amount of water from the lake at any elevation up to 20. The Hillsborough Canal and the proposed Palm Beach Canal are at present somewhat indefinite as to capacity. The Miami Canal will probably discharge twice as much water as it now carries after its rock section has been excavated to grade. It is safe to assume that the five canals above mentioned will, at elevation 19, carry approximately 2,600 cubic feet per second which, with the St. Lucie outlet, will give an aggregate capacity of 9,200 cubic feet per second. The capacities at elevation 16 will probably not exceed 6,000 cubic feet per second. The aggregate capacity at the higher level is equivalent to a depth of a little more than 0.04 foot per day on the lake surface, while at the lower level the draft will be 0.025 foot. Thus the average draft through the range of stage from 19 down to 16 feet above tide would be 566,000,000 cubic feet per day, and if no water flowed into the lake a period of 90 days would be required to reduce the level if all outlets were wide open. Of course no such record could be made because of the inflow into the lake. If 5,000 cubic feet per second were drawn through the St. Lucie inlet for power purposes and the other outlets from the lake closed except for incidental water uses, the storage provided between elevations 16 and 19 would suffice for about 139 days without consideration of added inflow supply.

It will be apparent that with the progress of the drainage work, which will include the deepening of the Miami Canal and the completion of the Hillsborough and Palm Beach Canals and the St. Lucie outlet, the outlet capacity from the lake will gradually increase so that the actual lowering of the lake can commence long before the total outlet capacity is achieved. While this is going on the rainstorms of the country will contribute the usual amount of water, the effect of which will be to maintain lake levels. Under these conditions it may be that, unless an unusually long dry season occurs, a year or more after the St. Lucie outlet is completed may elapse before the lake level is reduced to elevation 16. This gradual net reduction of the lake level during and after canal excavation, distributed over a period of four or five years, will not be without its peculiar advantages. A radical change of this kind in the natural conditions of a great area if quickly made is likely to cause many unforeseen contingencies. One of these which is apparent and important is the changed regimen of Kissimmee River. Such a change, if abruptly made, would cause heavy erosion of the river bed and banks and thereby an unknown but surely enormous quantity of débris would be discharged into the lake, impeding navigation and reducing in some degree its storage capacity. It would also cause local changes in river channel that might not be desirable. The orderly course of nature in making these great physiographic changes is extremely slow and it is well for man to copy nature's program as closely as possible.

SHRINKAGE OF MUCK.

Everglades muck in its present normal condition contains a large percentage of water. Numerous experiments and observations have been made to determine this percentage because the shrinkage that the muck will undergo by reason of the reduction of water content after drainage has very practical significance in determining upon the depth and general regimen of the canals and ditches. The most extensive series of experiments was that conducted by H. A. Kipp and F. F. Shafer in 1910 under the direction of the Office of Experiment Stations, United States Department of Agriculture. The results indicate a water content by volume of 60 to 90 per cent in the virgin muck at a depth below the surface of from 0 to 15 inches, and the approximate optimum water content for agriculture appeared to vary from about 48 per cent at the surface to 87 per cent at a depth of 35 inches. The purpose of the experiments was largely agricultural and the average shrinkage under drained conditions can only be inferred. Entire desiccation would reduce the depth of the muck to a very small fraction of its present depth, but it is obvious that no such condition would be considered in connection with agricultural operations. The reasonable assumption is that the average depth to water table should not exceed 4 feet, although it is admitted that at least one competent authority advocates greater depth. The final word on the subject can not now be given, but whether the ruling depth be 2 feet or 6 feet, it is obvious that the soil at the surface should probably contain from 40 to 50 per cent of water and the proportion should increase with the depth to the point of saturation. In other words, the total shrinkage will vary from about 50 per cent at the surface to 0 at or a few inches above the water table. It is impossible to determine precisely the mean shrinkage, but it is evident that it will not be as great as has occasionally been believed. The commission has made what it believes to be a reasonable assumption in the premises, and if it should prove that this assumption involves a comparatively wide error the difference in actual surface elevations will be inconsequential.

At the beginning of the commission's investigations boxes having a capacity of 1 cubic foot were filled with water-saturated muck, care being taken to avoid compacting the soil to a greater degree than that which existed before the soil was transferred to the boxes. These boxes were then placed in a dry location, sheltered from the direct rays of the sun, but exposed on all sides to the air. As the muck dried out the boxes were pried apart at the joints, so that the air could freely circulate between the sides and the surfaces of the muck block. At the end of about four months the muck was comparatively dry, though by no means desiccated. The shrinkage was uniform in all directions and the cubical dimensions were 8.5

inches. The reduction in volume was therefore about 65 per cent. The commission believes that a reasonable shrinkage factor will be approximated by assuming that the ultimate reduction in depth from surface to ruling water table under the partially saturated conditions that will prevail in practice will be the same as that above indicated for total drainage in the upper foot. Therefore the final plans herein presented are based on the assumption that the upper foot of muck will shrink vertically 7.8 inches, while the remainder of the column down to the water table will shrink not at all. Under this assumption the average condition will be fairly represented. It appears certain from general considerations based upon the commission's observations that the ultimate shrinkage will be no greater than that above indicated.

PERMANENCE OF WATERWAYS.

One of the prime factors in the successful operation of any drainage district is the permanence of the outlet canals. Any well-adjusted drainage system has its canals originally planned to a capacity sufficient to pass the ruling flood. Any substantial reduction during subsequent years means that the drainage system must become inadequate and agricultural development and operation must suffer accordingly. Loss of canal capacity may be the result of many causes, the most important of which are sloughing of canal banks, silting of channel, and the growth of weeds. In the Everglades where the muck banks of any canal must be relatively unstable, where erosion is easily accomplished, and where the semitropical water-weed growth is luxuriant, these items are of serious import. Therefore, the commission strongly recommends that all of these contingencies be prepared for at the outset. Prevention is better than cure. Laws and regulations governing the administration of this drainage district should contain strict provisions for canal maintenance. Each farmer should be required, under an inspection and penalty system, to properly maintain the lateral ditches which cross or adjoin his lands. For the maintenance of the larger canals the tax levy should include an item sufficiently large to provide for maintenance under drainage district control and supervision. When the entire district has been drained, a number of suitable dredges in constant operation will be required. Unless such provisions are made the district must within a few years revert to the swamp conditions which now prevail.

For the purpose of determining whether or not any of the main canals already constructed have lost any of their capacity, the acting drainage engineer of the State, at the request of the commission, caused to be made certain cross-section soundings at points at which such soundings had been made during excavations and at the close thereof. These canals have been practically "bank full" ever since they were opened. Consequently the water velocities have approached the maximum. Under ordinary conditions one might expect to find that the canals had been maintained to full capacity or even that they had in places enlarged themselves. Many of the sections were found to be as great as or greater than at the close of the excavation operations. Some of them, however, especially along the South New River Canal, showed marked silting and shallowing. If such results can occur under "bank full" conditions when scouring action must be at its maximum, a more pronounced loss of capacity may be expected in the future when under properly drained conditions in the Everglades the water in these canals will be lower than at present and the velocity reduced thereby.

VALUES OF "N."

In connection with the foregoing discussion it is proper to consider values of "*n*." This letter is a symbol used in the standard channel formula (the Kutter formula) to represent roughness of the sides and bottom of a canal. It is obvious that the rougher the sides and bottom the greater resistance to the passage of water and the slower the velocity of the water. The value of "*n*" therefore increases or decreases according as these surfaces are more or less rough, respectively. As the factor is an important one in connection with the practical planning of canal capacities in the Everglades, advantage has been taken of the canals already existent there to determine by experimentation the values of "*n*" under various conditions.

Values of "n" (Kutter formula) in the Miami, South New River, and North New River Canals.

Location.	Material.	Slope.	Area.	Velocity.	"R."	"*n*."
Barkleys	Muck	0.0000909	370.7	1.104	4.73	0.0378
Do	do	.0000946	358.5	1.11	4.63	.0377
Zona	Sand	.0000525	373.6	1.13	4.82	.0286
Do	do	.0000454	370.0	1.02	4.76	.0292
Everglades	Rock	.0000568	552.0	1.04	6.34	.0365
Do	do	.0000564	550.0	1.00	6.32	.0422
Do	do	.0000644	547.0	1.01	6.32	.0449

The engineer will readily recognize that the values of "*n*" expressed in the foregoing statement are, for the muck and rock conditions, unusually large. The commission has never seen the results of any observations in which the values of "*n*" are as great as those above set forth, yet these observations were made with the utmost care at three of the regularly-maintained current meter sections. The velocities determined conformed to those repeatedly observed at these stations. The slopes were determined by carefully checked level lines 1 mile long, which lines were bisected by the measurement station locations. Soundings were made along five cross sections, the middle one being the regular station cross section, and the others being made 100 and 200 feet above and below, respectively. Clearly the high values of "*n*" must be caused by marked lack of uniformity in the canal sides and bottom. Better excavation work would undoubtedly correct this condition, and the commission recommends that future canal work in the district be attended by more faithful inspection and a closer observation of neat grade lines than was obviously enforced in the work of the past. The commission believes, however, that under the difficult conditions in the Everglades it will be impossible in practice to achieve a lower value for "*n*" than 0.035. This value has therefore been used in planning all of the Everglades canals with the exception of the Okeechobee-St. Lucie Canal. This outlet will be excavated mainly in stable materials and there is no reason why under proper supervision and execution the value of "*n*" for this outlet should be greater than that conventionally assumed. Therefore the factor 0.027 has been used in the St. Lucie outlet.

METHODS OF EXCAVATING.

We have nothing original in the way of excavating machinery to recommend. We know of no excavator for muck, sand, and the lighter soils which will give more economical results than the hydraulic dredge.

For excavating rock under water the dipper dredge maintains its supremacy over any other device of which we have knowledge. The rock should be blasted in advance of the dredge, and a well designed and equipped drill scow is the best machine to use for drilling the rock to receive the explosives for this blasting.

Where—as will be the case in the prosecution of the work now under consideration—the volume of work justifies the investment, by the owner or agent, in the necessary mechanical equipment and other competent employees, the owner can prosecute a work of this magnitude at a less cost than the work is likely to be done by contract.

As soon as this work is staked out a dipper dredge with boom of sufficient length should be set to work to build a levee along the outer edge of each berm to hold back the material excavated from the channel by hydraulic dredge and prevent its flowing back into the channel.

Water power.—The construction of the channel which we advocate from Lake Okeechobee to St. Lucie introduces an element of value which does not enter into any other possible canal leading out of Lake Okeechobee. This channel, if constructed as we advise with a grade of two-tenths of a foot to the mile, will use up only 4.9 feet of 15.7 feet, the ascertained difference in level between the lowest permissible stage of the lake (16) and the ordinary stage of the St. Lucie River (0.3). We have designed this channel for a minimum flow of 5,000 cubic feet per second and that volume of water falling 10.8 feet will yield on an efficiency of 80 per cent 4,907 net electrical horsepower. This will be the minimum output, and it will be augmented by every inch of rise in the lake between the limits of control 16 to 19, and at the high stage will reach a maximum output of 6,270 horsepower. The cost of hydroelectric equipment and power house erected will approximate $210,000. The creation of a power such as this was not anticipated when the contract of April 30 was entered into, and hence no provisions was made therein for the preparation of plans and no exact estimate can be made until the plans in detail are prepared, but the estimate given herein is believed to be a reasonably close approximation. The value of this development (located in land remote from mineral fuel supply, and in which wood fuel is limited in amount and subject to consumption more rapid than the recreating powers of nature can make good) is self-evident, and it occurs in a locality from which it can radiate by suitable transmission lines to supply the ever growing need for power and light. One of the power needs to which it can be most fittingly supplied is that for operating pumps during the seasons when the reclaimed Everglades shall need irrigation.

The question of a constant supply of water for operating this power is a most momentous one.

The dry season over which our investigations have extended has been most unfortunate in its limitation of our hydrometric information to previous records to which we can not attach the value of proprietary knowledge, but in its bearing upon the water power problem it has given us a knowledge of very great value in reaching our conclusions. During the dry period, extending over the months of May to September, the discharge from Lake Okeechobee has never fallen below 1,350 cubic feet per second, and the mean discharge has been 2,115 cubic feet per second.

(NOTE.—The actual observations covered only four and one-half months).

We propose to divert the entire flow of Lake Okeechobee into the St. Lucie River through a canal at the easterly end of which we recommend the location of the before considered hydroelectric power plant. From this flow, of course, must be deducted the small volume needed for lockage and sometimes for irrigation.

Although the past season has not afforded us the demonstration of flood and run-off due to rainfall, which we had made rather elaborate preparations to observe and record, we are not left without a basis for determining with reasonable certainty the volume of flood waters that will be stored in Lake Okeechobee and the extent to which these stored waters can be drawn upon to develop water power.

Under the head "Lake Okeechobee run-off" and "Control of Lake Okeechobee," the data secured is discussed and the logical deductions from that data are stated. Note the references to the diagram entitled "Lake Okeechobee storage diagram, June 1–December 31, 1912."

We recommend the development of this water power as a proper conservation of a natural resource of great value now and likely to enhance in value as the years go by.

The channel considered in this discussion will carry 5,000 cubic feet of water with Lake Okeechobee at its low stage and that capacity increases as the lake rises until it has a capacity with the lake at 19 of 7,072 cubic feet per second. The discharge, however, is absolutely under control at the St. Lucie end of the canal.

It is proper to call attention to the fact that the approximate estimate of the cost of the proposed water power ($210,000) hereinbefore given, does not represent the entire cost; for to make this power possible the gradient used is two-tenths of a foot per mile, whereas a channel of smaller cross section would carry the same volume of flow, by reason of greater velocity, on a slope of five-tenths foot per mile, the difference in excavation, stated roundly, is 2,000,000 cubic yards, costing probably $200,000. This cost is a proper charge against the water power, and if it be added to the previous estimate the total cost would be $410,000 for an approximate minimum of 5,000 net electrical horsepower, or, say, $82 per horsepower, which is below the average cost of water powers in the Eastern and Middle States.

NAVIGATION.

As soon as the canals leading from Lake Okeechobee to tidewater were opened their use by motor boat and small water craft commenced and boats of moderate size can now ply between the Atlantic coast and the Gulf of Mexico via these canals, Lake Okeechobee, and the

Caloosahatchee River. Likewise there is now a water route from Lake Tohopekaliga to the Atlantic seaboard through the Kissimmee River, the lakes through which it flows—Lake Okeechobee and these new canals.

The proposed canal from Lake Okeechobee to the St. Lucie River will afford a channel of much greater commercial value than can ever be attained by the lesser channels of the drainage system. This channel will have a depth of 12 feet and a bottom width of 200 feet. At a distance of 24 miles from Lake Okeechobee it will discharge into the St. Lucie River, where it is proposed to construct a lock with a usable width of 30 feet and usable length of 130 feet. The St. Lucie inlet, by reason of its natural advantages, has been reported upon by the United States Engineers (see House Doc. No. 675, 62d Cong., 2d sess.), as deserving of development as a commercial port and harbor of refuge and Congress has accepted a project for its improvement and made initial appropriations for a development, estimated to cost $1,400,000. The opening of the channel which we recommended is looked upon most favorably by J. R. Slattery, major, Corps of Engineers, in charge of United States waterways in Florida. It is our belief that when this channel is determined upon and completion assured, Congress will recognize this construction as a link in a practicable waterway across Florida, provided without cost to the Government, and will proceed to improve the channel from Lake Okeechobee to the Gulf via the Caloosahatchee River, with depth equal to that which will obtain in the Okeechobee-St. Lucie Canal; thus providing an aid for marine commerce the need for which has been felt for generations past.

There should be a proper regulation of the speed of boats through these canals to safeguard the canal banks which under the speeds now permitted in the existing canals are being badly eroded by the swell from the passing boats. Five miles per hour in the smaller canals and 7 miles in the Okeechobee-St. Lucie Canal should be the limit.

SPECIFICATIONS.

(1) *Channel excavation.*—The channels hereinafter designated, both by geographical location and by Roman numerals, shall be excavated to the depths and widths called for in each case and according to the stakes set by the engineers of the board and to the bottom grades shown upon the profiles which will be exhibited previous to receiving proposals for the work upon which said proposals are asked.

(2) The excavations shall conform to the cross sections prescribed for each of the respective channels, and payment shall be made for material within the prescribed prism or prisms.

(3) *Disposition of material.*—The material excavated shall be deposited in equal quantities upon each bank of the channel being excavated, unless otherwise directed by the engineer.

(4) *Berm.*—A clear berm of 20 feet must be left on each side of the channel.

(5) *Prices.*—The prices bid for excavation must include the cost to the contractor of all clearing and grubbing and removal of obstructions in the line of the work upon the surface included between the spoil banks.

The unit prices bid must cover and include the providing and use of machinery and appliances of every kind necessary to the successful prosecution of the work; and it must also cover and include all explosives, materials, and supplies of every kind consumed or used upon the work, together with the cost of all labor, direction, and superintendence thereon or therefor. Briefly, the compensation paid to the contractor shall be the measured quantities of the several kinds of work done multiplied by the unit price bid upon the kind or classification of work to which the unit price applies.

Locks.—Sheet No. 1 (see p. 79) shows in plan, elevation, and cross section the lock designed for the outlet of the proposed Okeechobee-St. Lucie Canal. It is proposed to determine the location of this lock and to excavate the pit in which it is to be built and build the lock completely before the canal excavation reaches the site. Foundation of this lock to be as shown on the drawing. Details of the miter sills are shown on sheet No. 2 (see p. 80). The miter sills for standard locks are to be constructed exactly like those for the St. Lucie Lock only differing in length—the standard lock being narrower by 5 feet than the St. Lucie Lock. On sheet No. 3 (see p. 81) the construction of the lock gates is shown. The drawing is for the lower gates, and the upper or head gates will be of exactly similar construction but 10 feet shorter; the shortening to be from the bottom. Sheet No. 4 (see p. 82) shows in plan, elevation, and cross section the standard type of lock designed for canals now taking water from Lake Okeechobee, or in the process of construction for that purpose. They are the Miami Canal, the North New River Canal, the Hillsboro Canal, and the projected West Palm Beach Canal. It is proposed to build these locks in caissons, as indicated, and before the construction has advanced far enough to cause them to sink, to float them into exact position over foundations previously prepared and there sink them, making water-tight connections between the locks and the adjacent banks of the canal by rock-filled dam, or sheet piling and earth fill whichever may prove to be the most economical—other things being equal, preference to be given the rock-filled dam. After sinking, the concrete work, the placing of the gates, etc., will be completed; which done, the inside forms will be removed, the end bulkheads removed, and the lock will then be ready for service.

Should the State be required to build a lock in Three-Mile Canal, it must conform in type to the standard lock but in dimensions to the St. Lucie Lock.

FOUNDATIONS FOR THE STANDARD LOCKS.

(7) Foundations for the locks last described will be provided by driving piles and cutting them off at an elevation which will insure that the top of the miter sill, when the lock is in place, is at the elevation of the bottom grade of the canal at the distance from Lake Okeechobee selected for the lock site. The spaces between the pile heads must be filled in with small stone and stone screenings taken from the canal bank. As a preferred alternative to the pile foundation above described, all soft material

should be dredged from an area sufficient to receive the entire base of the lock and the excavation so made should then be filled with broken stone, taken from the rock sections of the canal, up to a level elevation, upon which the lock may rest with the top of its miter sills level with the bottom grade of the canal at that point in its length. The manner of preventing flow around the lock to be as hereinbefore described.

Sheet No. 5 illustrates the gates to be used for these standard locks and some of the cast-iron details to be used for all of the locks (see p. 83).

Sheet No. 6 illustrates the construction of filling and emptying valves, the cast-iron hollow quoins, wrought-iron straps, truss rods, pins, and anchors to be used for all gates (see p. 84).

Sheet No. 7 illustrates the gate-operating mechanism (see p. 85).

(8) No drawing is shown of the snubbing post to be set into the walls of the locks at the places indicated on the plan drawings by small circle with cross passing through center. These posts will be made of 5-inch gas pipe, 5 feet long, with coupling on lower end and cap on top. They must be bedded 4 feet 2 inches in the concrete and be filled with concrete before the cap is screwed on.

(9) *The dam across Okeechobee-St. Lucie Canal.*—The dam shall be constructed at the site selected by the board and shall be built in accordance with the drawings, sheet No. 8 (see pp. 86 and 87), and the following specification:

Piles shall be driven at the places indicated on the plans and cut off and capped as shown on the drawings. A line of triple-lap sheet piling (composed of boards 3 inches thick—the middle board to be dressed on one side to insure uniform thickness throughout) shall be driven as indicated on drawing 8, on the downstream side of the upstream row of bearing piles extending throughout the entire length of the dam and continuing across the entire width of the lock foundation. The masonry of the dam shall be bonded into the masonry of the lock and its northern end shall be bonded into the bulkhead as shown on drawings. The concrete in this entire structure shall conform to the standard concrete specifications hereinbefore prescribed for lock construction. The reenforcing rods used shall be of dimensions shown upon the drawings.

(10) *Caps.*—The caps on top of piles shall be secured to the piles by square steel drift bolts, driven in holes bored to receive them. Drift bolts must be 1⅛ inches square and long enough to penetrate 10 inches into the vertical center of the pile. Holes to receive these drift bolts must be bored with a seven-eighths-inch auger.

PLANS.

(11) *Checking plans.*—All of the accompanying plans shall be carefully checked by the contractor before the beginning of the work. Should any errors be discovered, the engineer's attention shall be called to the same and corrections made; after which, the contractor shall be responsible for any errors that may occur or which may have occurred. The accompanying plans form a part of these specifications, and, in the event of any discrepancy between the plans and these specifications, the judgment of the engineer shall be decisive thereon. The figured dimensions on the plans are to be taken where given, whether they do or do not agree with the dimensions obtained by scaling from the drawings, provided that such dimensions shall be checked by the contractor.

(12) *Detail drawings.*—With the general drawings submitted as a guide, all detail and shop plans required shall be made at the expense of the contractor. They shall have a uniform size of 26 inches by 40 inches, inside border lines, with a border margin of 1½ inches on the left-hand edge and one-half on all other edges. Small or irregular sized sheets not of standard dimensions will not be accepted for approval. Shop plans shall have noted on each sheet all requirements as to reaming, drilling, milling, planing, riveting, painting, and any special treatment to be given the work shown on such sheet and also any other explanatory notes that are necessary for the proper understanding of the work to be done in the shop in accordance with the specifications and contract drawings. The contractor shall prepare complete general erection plans showing all metal work furnished, with all shop marks, dimensions, and elevations necessary for guidance in the proper setting of same. The contractor shall furnish the board with duplicate copies of all shop bills of materials, showing calculated weights of all material or the scale weight of same.

(13) *Approval of plans.*—All plans made by the contractor shall be submitted for approval and shall be approved by the chief engineer or other designated engineer of the board. Two prints of each drawing shall be submitted to the board for examination and, if found correct, will be approved by the engineer of the board, and no work shall be done, shown on any drawings, until such drawings have been approved as last above specified. No alterations of any drawing shall be made by the contractor

after they have been approved without the written consent of the engineer. The contractor shall furnish the board, as requested, and without extra charge therefor, six complete sets of prints of all drawings, as approved, for office files, for the inspectors, and for use in the field. After completion of this contract the contractor shall furnish the board, free of charge, one complete set of Vandyke negatives of all shop plans and of all other plans of the work hereunder not furnished by the board, corrected to show all final changes thereon and to show the work as finally fabricated and erected.

(14) The approval of any drawing shall not relieve the contractor from the responsibility for any errors thereon nor from any cost or expense of making changes or corrections in the shop or after delivery due to, or on account of, errors on any drawings. Any cutting or drilling of metal work, masonry, timber, or other work necessary to allow erection of any material, due to errors in the plans or in fabrication of the metal work, or on account of any interference of any of the parts of the work, shall be done at the expense of the contractor.

QUALITY OF MATERIALS.

All materials to be used in the work are to be the best of their respective kinds or grades.

(15) All steel shall be made by the basic or acid open-hearth process and shall be of grades known as "structural steel," "rivet steel," "steel castings," and "steel forgings."

(16) The chemical and physical properties of steel shall conform to the following limits:

Elements considered.	Structural steel.	Rivet steel.	Steel castings.	Steel forgings.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Phosphorous maximum	0.04	0.04	0.05	0.06
Basic acid	.05	.04	.06	.06
Sulphur maximum	.05	.04	.05	.05

	Ultimate tensile strength.			
	Desired.		Not less than—	
	Structural steel.	Rivet steel.	Steel castings.	Steel forgings.
Pounds per square inch	60,000	50,000	65,000	60,000.
Elongation:				
Minimum per cent in 8 inches (fig. 1).	1,500,000	1,500,000		
Minimum per cent in 2 inches (fig. 2).			20 per cent	26 per cent.
Character of fracture			Silky or fine granular.	Silky.
Cold bends without	180° flat	180° flat	90° d 2 t	180° d t.

(17) The elastic limit shall not be less than 55 per cent of the ultimate strength.

(18) If the ultimate strength varies more than 4,000 pounds from the desired a retest shall be made which, to be acceptable, shall be within 5,000 pounds of the desired ultimate.

(19) Chemical determinations of the percentage of carbon, phosphorus, sulphur, and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analysis shall be made from finished material, if called for by the board, in which case an excess of 25 per cent above the required limit will be allowed.

(20) *Structural steel.*—Specimens for tensile and bending tests for plates, shapes, and bars shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to a standard form shown by Figure 1, or with both edges parallel, or they may be turned to a diameter of three-fourths inch for a length of at least 9 inches, with enlarged ends.

(21) *Rivets.*—Rivet rods shall be tested as rolled.

(22) *Steel castings.*—The number of tests for steel castings will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from sink heads, if the sink heads are of sufficient size. The coupon or sink head shall be annealed with the casting before it is cut off. The specimens for tensile tests shall be turned to the standard form shown by figure 2. The specimens for bending tests shall be 1 inch by one-half inch in section.

(23) *Steel forgings.*—The specimens for tensile and bending tests shall be the same as for steel castings.

Tests will be required from each furnace heat in the case of eyebar material. The eyebars required for full-size tests, if made, and those required for the structure shall be made at one time. The test bars, to be selected by the inspector, must be fair average specimens of those which would be classed as good bars, acceptable for the work. No bar which is known to be defective in any way shall be selected for testing. These bars will be required to develop a minimum stretch of 12½ per cent before breaking, the elongation to be measured on the gauged length of the constant section of the bar, including fracture. A failure in the requirements for elongation, as given here and in the table, will be sufficient cause for condemning the bars represented by the test. All bars will be required to break in the body. No welds will be allowed in eyebars. Eyebars for full-size tests, when tested to destruction, shall be paid for at cost, less scrap value to contractor, if the test proves satisfactory; otherwise, they will be considered as rejected material and shall be entirely at the expense of the contractor.

(24) Material which is to be used without annealing or further treatment shall be tested in the condition in which it is to be used. When material is to be annealed, or otherwise treated before use, the specimens for tensile tests representing such material shall be cut from properly annealed or treated short lengths of the full section of the bar, or from coupons annealed with the casting.

(25) *Bending.*—Bending tests may be made by pressure or by blows. Rivet steel, when nicked and bent around a bar of same diameter as the rivet rod, shall give a gradual break and a fine, silky uniform fracture.

(26). *Tensile.*—At least one tensile and one bending test shall be made from each melt of steel. When more than one class of material is taken from any melt, each variety shall be separately tested. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Rivet steel and other small parts may be bundled with the above marks on an attached metal tag.

(27) Materials which, subsequent to the above tests at the mills and in acceptance there, develop weak spots, brittleness, cracks, or other imperfections, or are found to have injurious defects, shall be rejected at the shop and shall be replaced by the manufacturer at his own cost.

(28) *Steel castings.*—All steel castings shall be as free as possible from blowholes, true to pattern and size, and of good finish. Any casting having blowholes or other defects which impair its strength shall be rejected. All steel castings shall be annealed and shall be properly supported to prevent warping during the process of annealing.

(29) *Cast iron.*—Cast iron must be of the best quality of tough gray iron, manufactured from pig and not from scrap iron. Castings must be true to pattern, out of wind, free from flaws, blowholes, sand pockets, cracks, imperfections, ragged edges, excessive shrinkage, or any other defects impairing their efficiency or appearance. Tests shall be made on the "arbitration bar" of the American Society for Testing Materials, which is a round bar 1¼ inches in diameter and 15 inches long. The transverse test shall be made on a supposed length of 12 inches with load at middle. The minimum breaking load shall be 2,900 pounds, with a deflection of at least one-tenth inch before rupture.

(30) Tobin bronze, phosphor bronze, and babbitt, or any special metal, shall be of the best quality of materials suitable for the purpose. The brand or formula for each shall be submitted to and shall be approved by the engineer.

(31) All patterns shall be finished to give a neat appearance to the castings. The outer unfinished edges of all ribs, bases, etc., shall be rounded off to a radius of one-fourth of the thickness of the metal in same, and the inside corners shall be fitted with wood fillets well fastened and rounded out to a radius of at least one-half the thickness of the thinnest rib forming the corners. All patterns shall be delivered in good condition to the board where directed by the engineer, free of extra charge. A full list of the patterns delivered shall be furnished to the engineer.

LOCK GATES.

(32) The lock gates and gate-operating machinery shall be finished and erected and placed in complete working order.

(33) The miter sills shall be of sound, straight, square-edged white-oak timber, 14 by 16 inches, framed accurately and secured in place as shown on the plans. The anchor bolts will be set with upper ends loose in the concrete. Recesses will be left in the floor of the lock for miter sills. The miter sills shall be bedded in Portland-cement mortar in these recesses and fitted to an even bearing against the lock gates after the gates have been properly hung. The anchor bolts and miter sills shall then be grouted in place to the satisfaction of the engineer.

(34) The timber used in the gates shall be either cypress, long-leaf yellow pine, or Douglas fir. Materials shall be sound and straight, square edged and out of wind, free from decay, large checks or splits, large, loose, or unsound knots, and shall contain not less than 80 per cent of heart. All timber and lumber shall be dressed throughout true to finished sizes, framed and put together neatly and accurately. The metal work shall be properly fitted to the gates and the character of the metal used shall conform to the specifications hereinbefore given for the several kinds of work.

(35) The quoin post of each gate shall be finished to fit accurately into the hollow of the quoin when the gate is in closed position and the center of curved face of quoin post at the top of the gate shall be directly above the center of the pintle in base casting of quoin. The center of the pin at top of gate, about which the gate swings, is eccentric by one-quarter inch in such a way that as the gate passes from the closed to the open position it swings away from its bearings upon the quoin. Care must be taken that this condition is accurately attained and that eyebolts at the top pin are properly adjusted.

(36) The miter post of each gate must be accurately finished to a vertical plane surface lying in the axis of the lock so that surfaces of contact of the two leaves will form a water-tight joint when bearing against the miter sill.

(37) The horizontal frames shall be accurately and strongly framed into the quoin and miter posts and iron straps shall be flush with the timber surfaces.

(38) Sheathing shall be of the size shown on the plans, surfaced on two sides and matched and shall be laid up tight to form water-tight joints.

(39) Step castings shall be of cast steel of the grade hereinbefore specified. The surfaces bearing on the curved surfaces of the quoins shall be accurately finished to radius called for. The holes for pintles shall be accurately turned or bored and then polished to a smooth finish. The bronze bearing disks shall be finished on one face to a concave surface of radius shown and polished all over. The lower surfaces of step castings shall be finished, care being taken to maintain clearance, as shown, between the step and the base casting of the quoin.

(40) The plate at the top hinge of the gate, joining the horizontal frame and the quoin post, is to be welded into shapes shown and finished to the radius of the quoin post without materially reducing the thickness of the plate at any point.

(41) All valves are to be accurately made and carefully fitted to their frames with a minimum clearance for leakage. They shall be so adjusted that they can be opened and closed easily by the means indicated on the plans. The handles of all levers are to be at the same elevation above the walk in their extreme positions.

(42) All finished surfaces of metal work shall be coated with white lead and tallow before taking out of shop. All other surfaces of metal shall be painted before leaving the shop. All surfaces of timber in contact shall be coated with thick white lead, or other approved material, before the gates are assembled. All bolt holes in timber shall be swabbed out carefully and all surfaces of all bolts and washers shall receive a heavy coat of approved paint just before assembling. All surfaces of metal work that will be inaccessible after erection shall receive two coats before assembling in the gates. After erection all surfaces of timber that will remain permanently exposed when the water is admitted and all surfaces of metal work on the gates shall be painted three coats of approved paint.

(43) *Piles.*—All foundation piles supporting masonry, if ordered to be used anywhere in the work, shall be   , and all others must be of   or   . They must be sound and straight, not less than 14 inches at the butt nor less than 9 inches at the small end, and must taper uniformly from end to end. Piles for the foundations are to be used of such length that they may be driven to rest upon solid rock or hard bottom. All piles must be driven with a steam hammer, unless otherwise permitted by the engineer, and, if used for foundations, shall be driven to refusal on rock or hard substratum. If necessary, in order to drive to hard bottom, a follower and guide box or extension leaders shall be used. If in the opinion of the engineer any piles prove

imperfect or become unfit for use under the hammer, or are not driven straight, they must be removed by the contractor without extra cost. If so directed by the engineer, the piles shall have the bark removed. Should any of the piles rise or change their position after being driven they shall be redriven, if so directed by the engineer, at the expense of the contractor: *Provided*, That if the piles are driven in such a manner and in such order as, in the opinion of the engineer, to cause the least liability of displacement or raising of piles already driven, or if driven in the manner and order directed by the engineer, then the cost of redriving such raised or displaced piles shall be paid for at actual cost with 15 per cent added. All piles must be cut level and at the proper elevation. Payment for piles in foundations and in permanent protections and docking will be made on the following basis:

First. Per linear foot for all piles delivered on the order of the engineer at the site of the work.

Second. For all piles driven, per linear foot of that portion below the point of cut-off.

No payment shall be made for piles excepting in foundations, permanent protections and docking, unless ordered by the Engineer in writing. The cost of all chain, cable or other iron in protection clumps, shall be included in the price for protection piles driven in place and named in the bid. All temporary protection piles or timber in clumps, or otherwise, placed around the cofferdams or the substructure at any time prior to the completion of the work shall be placed and removed at the expense of the contractor free of cost to the board.

(44) *Sheet piles.*—Sheet piles shall be fabricated of three boards spiked together, so as to form that section commonly called "triple lap sheeting." These boards shall be of lengths to be indicated upon bills for material to be given the contractor. They shall not be less than 10 inches wide and 3 inches thick. The middle board—of the same width as the two outside boards, shall be run through a planer to insure a uniform thickness of 2⅞ inches, and this middle board shall project on one side 2 inches beyond the edges of the two outside boards and parallel thereto, forming a tongue, leaving a corresponding recess or groove on the other side. These boards shall be spiked together with steel boat spikes three-eighth inches square, 8 inches long, two at head of each pile on opposite sides and 4 inches from the top and two at bottom and in the length between top and bottom on each side a spike every 30 inches, staggered. Half of these spikes should enter the pile on one of its broad sides and half on the other.

The point end of these piles must be sawed off at an angle of 45° and, when driven, the point thus formed must be next to the pile last driven, so as to force it close in to said last driven pile and aid in making a tight joint, the tongues and grooves of adjacent piles fitting into each other.

(45) *Timber.*—All timber used in locks, anchors, sheeting, wales, fenders, or elsewhere must be sound, straight, and free from any defects which might impair its strength or durability, and be of such variety and dimensions as hereinafter specified or shown on drawings.

(46) The inspection of timber must depend largely upon the judgment of the inspector, and while the within requirements are given for general guidance as to the class of material desired, the acceptance of any piece of material must depend upon the inspector's judgment as to its strength when in place. The intent of these specifications is that only strong and sound pieces shall be accepted, and where any defects herein admitted are so situated as to impair the strength of any piece for the purpose for which it is to be used in the structure, such piece shall not be accepted.

(47) All timber will be inspected at the site of the work as it is put in place, and if found not to conform with the requirements of the plans and specifications, shall be removed from the premises: *Provided, however*, That should the contractor desire to have timber inspected at other points, such inspection shall be made subject to restrictions as the engineer may require and the extra cost of same to the board shall be paid by the contractor or may be deducted from any amounts to be paid to the contractor under this contract.

(48) *Stone.*—All broken stone for concrete shall be as nearly as possible cubical in shape, free from dirt or other foreign substances, and must be screened free from flat chips or dust. Stones shall not be larger than 1 inch in any direction, and shall be in quality subject to the approval of the engineer.

(49) *Cement.*—The best Portland cement only shall be used throughout this work, brand and quality to have a well-sustained reputation for excellence, and to be subject to the approval of the engineer, who shall cause to be made such tests as are considered the best and most modern practice in cement testing and as may seem to him proper for determining the quality of the cement. The weight of cement shall not be less than 95 pounds per cubic foot. All lumpy, dirty, or damaged cement shall be rejected; also all damaged or short-weight packages. All rejected cement shall be

immediately removed from the site of the work. The contractor shall provide storage capacity for at least 10 days' supply and shall store the cement so as to give easy access for the procurement of samples for tests.

(50) *Sand.*—The sand shall be sharp and clean, free from all clay, loam, or gravel, and of a quality approved by the engineer. Sand shall be coarse for concrete and mortar. For grout in pit linings it may be finer or shall be screened as the engineer will permit.

(51) *Concrete.*—All concrete used in any lock, dam, or other structure required for this work, unless otherwise specified, shall consist of one part cement, two and one-half parts sand, and five parts screened broken stone, bulk measure, not less than 95 pounds of cement to be taken as a cubic foot. Stone shall be moistened before mixing if the engineer so directs. The mass must be turned over often enough to thoroughly incorporate, using a mechanical mixer of type approved by the engineer. If the engineer will permit, the mixing of the concrete may be done by hand on suitable platforms, in which case the cement and sand shall first be thoroughly mixed dry, after which the stone, properly moistened, shall be added with sufficient clean water to make the whole mass, when thoroughly mixed, a tenacious and quaking mixture without surplus water. The concrete shall be immediately conveyed to the proper place in the work in large buckets, boxes, or barrows, or by other means, satisfactory to the engineer, which will not tend to impair the uniformity of the mixture. The concrete shall be deposited in layers not over 12 inches thick, each layer to be thoroughly and compactly tamped until the whole is perfectly solid and free mortar appears on the surface. The material forming all exposed surfaces, excepting such as are to be lined or faced, shall be so placed as to present a solid, smooth finish when the forms are removed and, if the engineer so directs, surfaces found to be rough or porous shall be neatly dressed, or pointed with mortar of the quality specified for pointing, free of cost to the board. No retempering of concrete will be allowed. All loose stone and foreign material lying on the old concrete must be removed and the surface thoroughly drenched with clean water before laying any new concrete thereon. No concrete shall be placed on any surafce until a new surface has been picked thereon and properly moistened. Should any concrete become covered with dirt, grease, or other substance that will prevent proper adhesion to new concrete, a new surface shall be picked thereon and properly moistened. All dead concrete must be removed from the work.

(52) *Forms for concrete.*—The contractor shall furnish all forms necessary for the concrete and mortar facing in the substructure. They shall be built true to lines and dimensions, of plank of sufficient thickness (not less than 2 inches), surfaced on one side, and so efficiently braced that they will retain their position and line until all concrete which shall be against them has been placed and has set. All inside forms shall be removed by the contractor before flooding the structures. The cost of all forms with necessary bracing shall be included in the price for concrete named in the bid.

GENERAL CONDITIONS.

(53) *Examination of site.*—Prospective bidders for this work are required to carefully examine the site selected for the structure on which proposals are invited in order to inform himself, or themselves, as to the magnitude and nature of all of the contemplated work and also the facilities for the delivery of material at the site. No plea of ignorance of what is required as a result of failure to make the proper examinations or to discover the conditions at the chosen site will in any case be accepted as a sufficient excuse for any failure or omission on the part of the contractor to fulfill in every detail all the requirements of this contract. Should any part of these specifications be deficient or not clearly expressed, parties making the bids shall apply to the engineer, in writing, for all necessary information before the bids are submitted.

(54) *Measurement.*—Measurement of all masonry shall be by the cubic yard, and all payments shall be made upon the actual cubical contents of the contemplated masonry within the lines as shown on the plans. Measurement of all materials shall be in accordance with the units of the measurements as herein specified.

(55) *Quality.*—All material shall be the best quality of its kind and all workmanship shall be first class. Any material or workmanship which does not satisfy the requirements of these specifications may be rejected by the engineer at any time before the acceptance of the work, and the contractor shall make good all deficiencies at his own cost. The fact that the authorized inspectors have inspected said material or workmanship shall not make the board liable for extra cost for replacing the same with material or workmanship accepted by the engineer on final acceptance.

(56) *Drawings.*—The drawings furnished form a part of these specifications, and any work shown thereon shall be executed the same as if mentioned herein. The

work is to be made complete and to the satisfaction of the engineer, notwithstanding any omissions in plans or specifications.

(57) *Quantities.*—The quantity of work and material figured from the plans is approximate, where quantities are shown, and the board reserves the right to make any changes in the plans or specifications which may be deemed necessary, either before or after beginning the construction thereof: *Provided*, That if alterations are made, the general character of the work as a whole is not changed thereby. If such alterations increase the quantity of the work to be done, such increase shall be paid for according to the quantity of the work actually done and at prices and rates established for such work under this contract. If such alterations diminish the quantity of work to be done, they shall not constitute a claim for damages nor for anticipated profits on the work that may be dispensed with; and in case lump-sum prices are to be paid for work under this contract, the board shall receive credit for work omitted, at a fair price, to be fixed by the engineer. Notice of change of plan must be given to the contractor in writing, and it is expressly agreed that no alterations or additions or extra work are to be paid for unless so directed in writing.

(58) *Extra work.*—All claims for extra labor or material furnished by the contractor, or for damages from any causes whatever, must be reported to the engineer at the time such labor or material is furnished or such damages occur, and they must also be presented to him in writing at the end of the month: *Provided*, That nothing shall be paid for as extra work that can be classified under any of the heads upon which prices are fixed by this contract. When so required, the contractor shall deliver to the engineer each day a signed statement of the extra labor and material furnished during that day. Whenever work is required to be done which is not now contemplated or covered by the prices hereinafter given, the engineer shall fix such prices for the work as he shall consider just and equitable, and the contractor shall abide by such prices, provided he enters upon such work with a full knowledge of the prices so fixed by the said engineer; but if the contractor declines executing said work at the prices fixed by said engineer, then the board may enter into contract with any person or persons for its execution the same as if this contract had never existed; and if extra work or work not provided for in the contract is performed by the contractor before the prices have been fixed for such work, then the engineer shall estimate the same at such prices as he shall deem just and reasonable, and his decision shall be final, and the said contractor shall accept such prices in full satisfaction of all the demands against the board for said extra work: *Provided*, That, if the extra work done under this contract is of such a nature, being distinct from other work being done by said contractor, that the actual cost of the same can be determined, then the said contractor shall receive, and the board shall pay, in full satisfaction for the same, the actual cost of the work estimated as hereinafter specified with 15 per cent added for superintendence, use of tools, and profit: *Provided further*, That nothing shall be deemed extra work which can be measured or estimated under the provisions of this contract.

(59) *Decision of engineer.*—It is further agreed that in cases of question or dispute arising or growing out of this contract in any way regarding the cost or value of extras, variations, allowances, deductions, or the amount of damages in any manner growing out of the violation of this contract, the decision of the engineer shall be final, binding on both parties hereto. In estimating the cost of extra work the cost of material shall be the actual price paid for the same delivered at site of the work. The cost of labor shall be taken as amounts paid for same as shown by the pay rolls, with the cost of insurance added when such case can be shown to have been paid. No charge for cost of administration will be allowed. All work provided for in this contract is to be done under the direction and supervision of the engineer and his properly authorized agents. The contractor is to be guided by the lines, stakes, marks, and grades given by them, and is to carefully preserve the same as far as possible during the progress of the work, and is to furnish all needed facilities, without extra charge therefor, to enable the engineer to properly give lines and grades and measures of the work from time to time.

(60) *Inspection.*—All materials of whatever kind to be used in the work will be subject to the inspection and approval of the engineer. All unsuitable or rejected materials must be removed from the premises at once by the contractor.

(61) All work shall be subject to constant inspection before acceptance. Any unfaithful or imperfect work that may be discovered before its final acceptance shall be corrected immediately, and any unsatisfactory materials used in the work shall be rejected and removed on the requirement of the engineer, notwithstanding they may have been overlooked and estimated. The inspection of any work shall not relieve the contractor of any of his obligations to perform sound work, as herein

specified, and all work which, during its progress and before its final acceptance, may become damaged from any cause, shall be removed and replaced by good and satisfactory work.

(62) *Responsibility.*—The contractor will be responsible for the entire work until completed and accepted by the board. The contractor will be required to give his personal attention to the fulfillment of this contract and to the execution of the work. He is to keep the same under his control, and will not be allowed to sublet all or any part of it, it being distinctly understood and agreed that the subletting of the work covered by this contract, or any part thereof, shall, after 30 days' notice, work a forfeiture of the contract at the option of the board.

(63) *Legal action.*—In the event of any action of law or in equity being taken by any person, persons, or corporation, which would restrain the board from giving or the contractor from securing possession of the site chosen, or in any way delay the execution of this contract, then, in that case, the contractor shall not hold the board liable for any loss or damage by him sustained on account of such interference, and the contractor shall be accorded an extension of the period within which the work was to have been completed by the terms of this contract equal to the time lost by reason of such restraint.

(64) *Contract may not be assigned.*—The contractor, will not be allowed to assign, by power of attorney or otherwise, any portion of the moneys that may become due through the workings of this contract. In the case the contractor fails to comply with the provisions of this contract as to progress and character of work, he shall be duly notified in writing, and 30 days after the giving of said notice the board may declare this contract forfeited, if there is a substantial failure to comply with its provisions.

(65) *Equipment to be furnished.*—The contractor is to furnish all the tools of every description, including pumps, cars and tracks, boats, barges, and tugs necessary to the full and complete carrying out of this contract, and on completion of the work is to remove all tools, buildings, and materials of all kinds from the site of the work.

(66) *Precautions.*—Whatever precautions may be necessary to render any portion of the work more secure in any respect, or to decrease the liability of accident from any cause, or to avoid contingencies which are liable to delay the completion of the work, shall be taken by the contractor.

(67) *Competent employees.*—The contractor shall employ competent foremen and laborers and shall discharge, at the request of the engineer, any incompetent or unfaithful men in his employ. None but men expert in their respective branches of work shall be employed where special skill is required.

(68) *Liability for damages.*—If any damage shall be done by the contractor, or by any person or persons in his employ, to the owner or occupants of land, or to any property adjoining the vicinity of the work herein contracted to be done, or to a neighboring contractor, the engineer shall have the right to estimate the amount of such damage, and to cause the board to pay the same to the said owner or occupant, and the amount so paid for said damages shall be deducted from the money due said contractor under this contract. Said contractor covenants and agrees to pay all damages for any personal injury sustained by any person growing out of any act or doing of himself or his employees that is in the nature of a legal liability, and he hereby agrees to indemnify and to save the board harmless against all suits or actions of every name and description brought against the said board for, or an account of, any such injuries or such damages received or sustained by any person or persons, by or from said contractor, his servant or employees, in the execution of said work; or by or in consequence of any negligence in guarding the same; or by or on account of any omission or act of said contractor, his agents or employees; and the said contractor further agrees that so much of the money due to him and by virtue of this contract as shall be considered necessary by the board may be retained by said board until such suit or claim for damages, as aforesaid, shall have been settled and evidence to that effect furnished to the satisfaction of the said board.

The foregoing specifications do not enter into the minuter details of construction but must be supplemented by those detailed drawings which they require the contractor to provide.

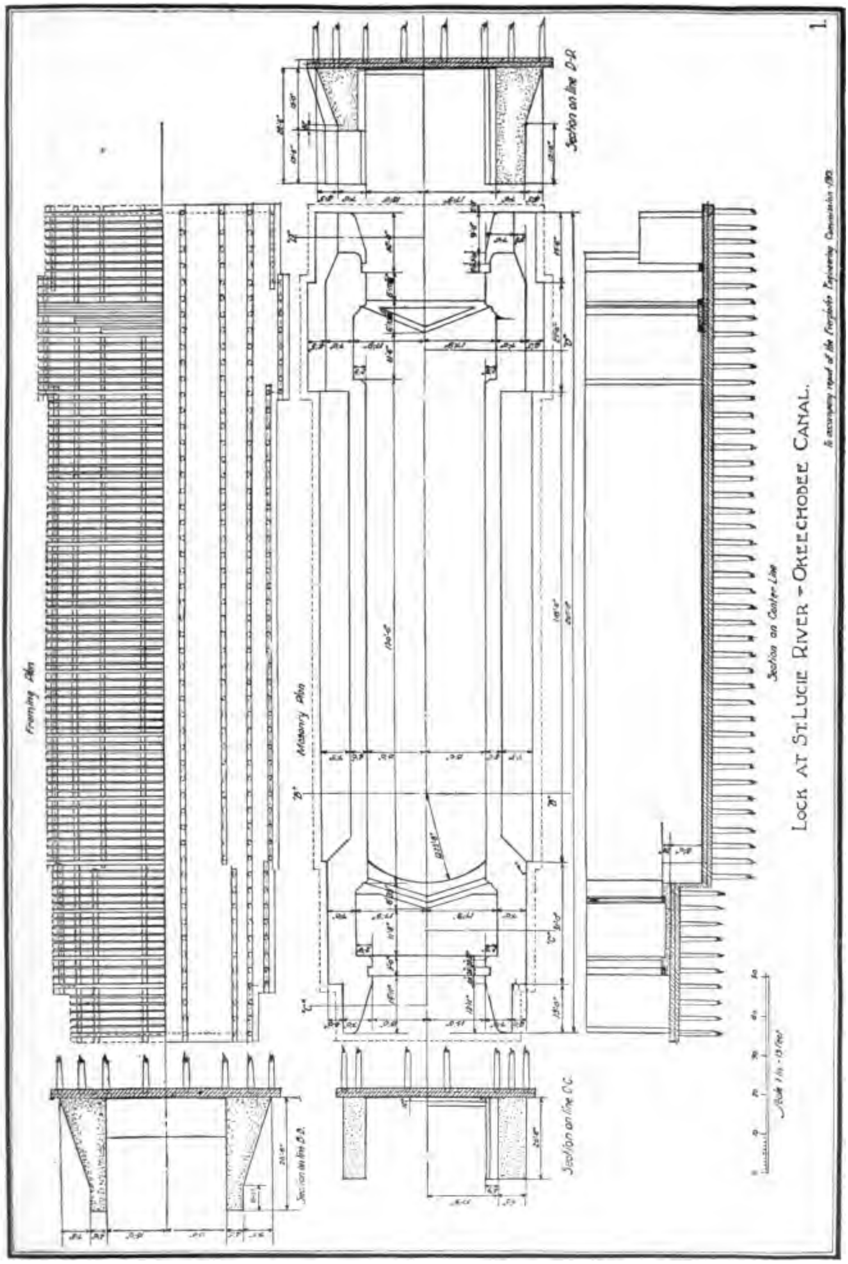
The foregoing specifications are, for the most part, adopted from standard specifications for work with which a member of the commission has been responsibly connected.

USE OF LOCKS TO RELIEVE EXCESS FLOODS IN THE LAKE.

We do not consider it necessary to provide a single channel large enough to carry the maximum flood that under a possible coincidence of conditions may occur. Under such conditions we advise the temporary use of all of the canals leading out of Lake Okeechobee. To accomplish this, stop logs should be placed in the pocket provided at the downstream end of the lock to raise the head in the locks to the upstream level. Then the gates should be opened fully and secured in their open condition; the stop logs should then be removed and a free flow permitted through the locks. When the emergency is over, recourse should again be had to the stop logs to make it possible to close the gates and restore normal conditions. Then the logs should be removed.

All of which is respectfully submitted.

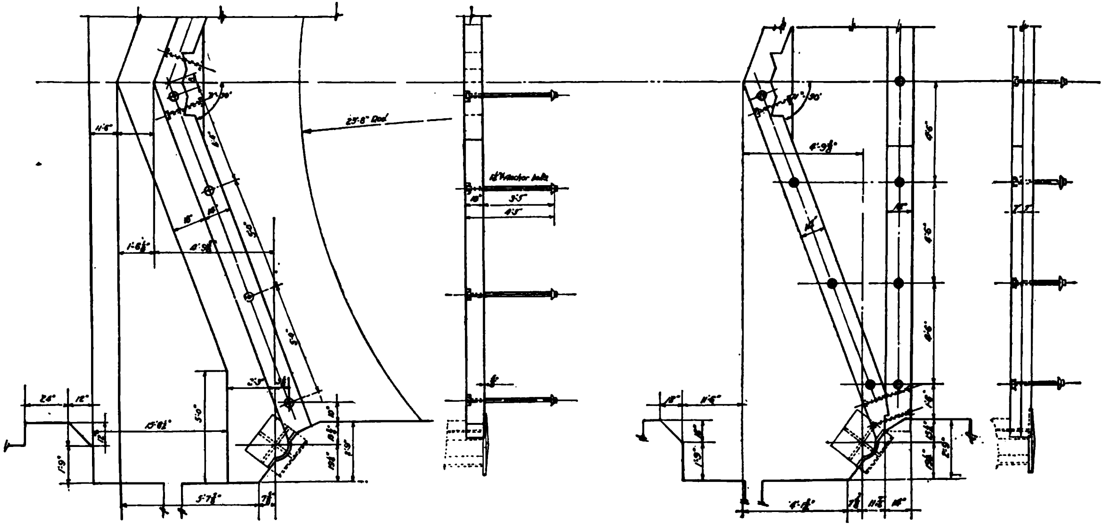
ISHAM RANDOLPH,
Chairman.
M. O. LEIGHTON,
Commissioner.
EDMUND T. PERKINS,
Commissioner.



LOCK AT ST. LUCIE RIVER – OKEECHOBEE CANAL.

To accompany report of the Everglades Engineering Commission 1913

DETAIL OF MITRE SILLS
ST. LUCIE LOCK

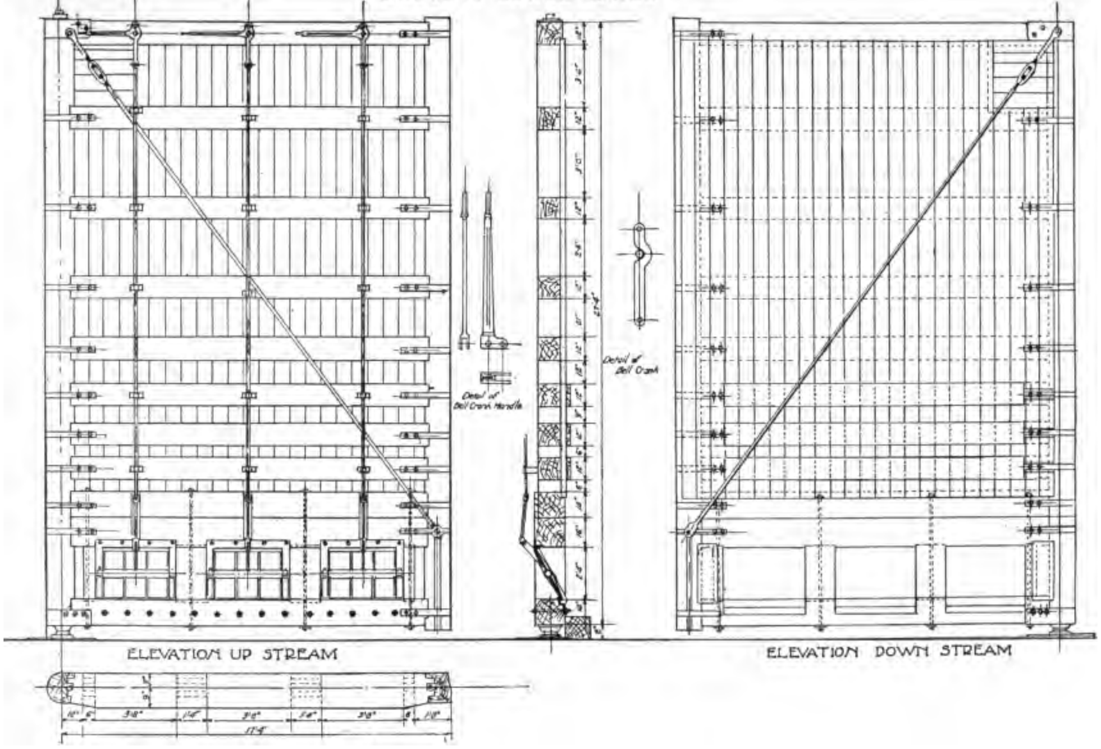


To accompany report of the Everglades Engineering Commission 1913.

2.

ST. LUCIE LOCK

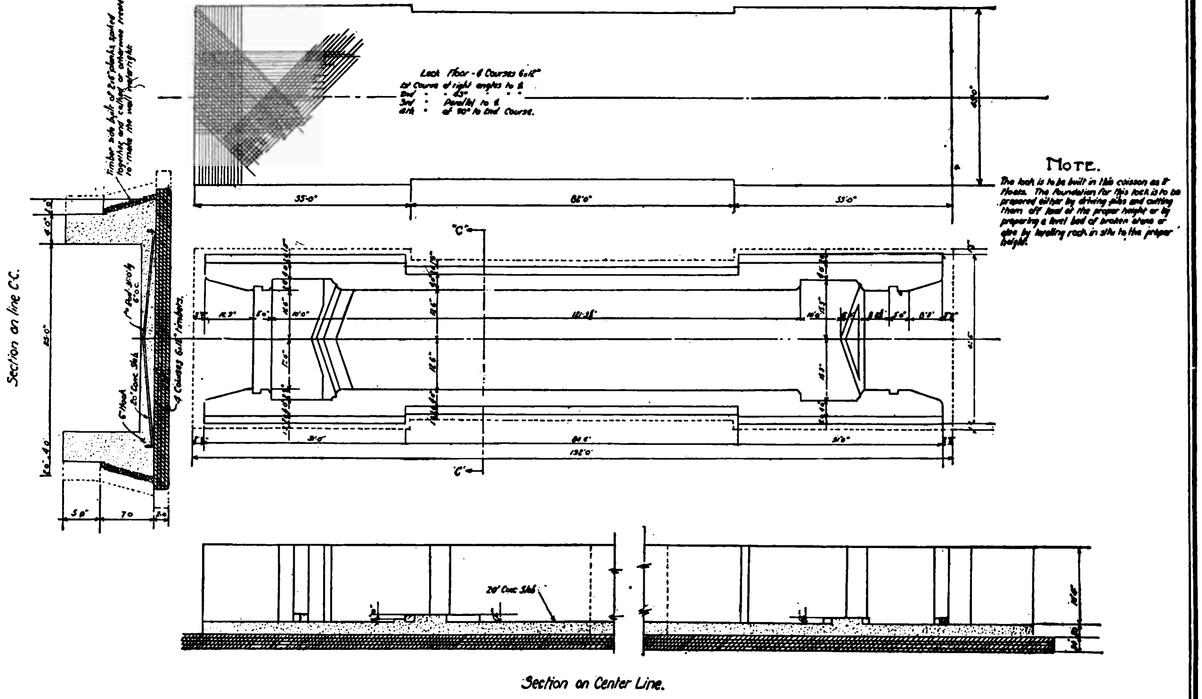
DETAIL OF LOWER GATES



To accompany report of the Everglades Engineering Commission 1913.

3.

STANDARD LOCK FOR CANALS
FLOWING SOUTH FROM
LAKE OKEECHOBEE.



Lock Floor - 4 Courses 6x12"
1st Course at right angles to ℄
2nd " " 45° " " "
3rd " Parallel to ℄
4th " at 90° to 2nd Course.

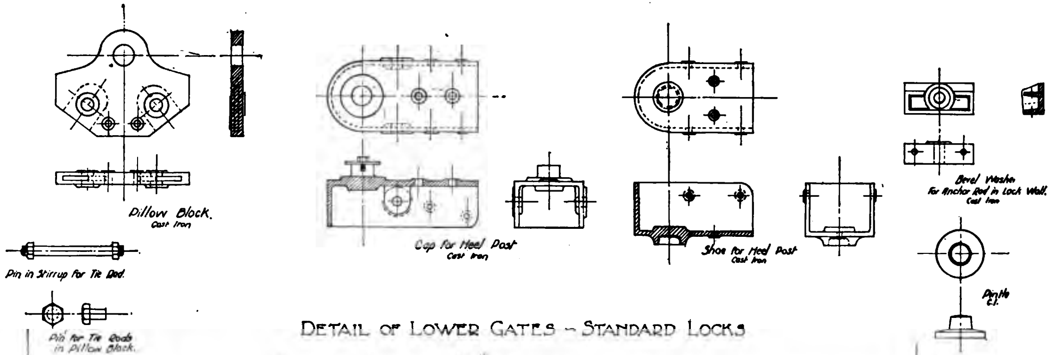
NOTE.

The lock is to be built in this caisson as it floats. The foundation for this lock is to be prepared either by driving piles and cutting them off level at the proper height or by preparing a level bed of broken stone or else by leveling rock in situ to the proper height.

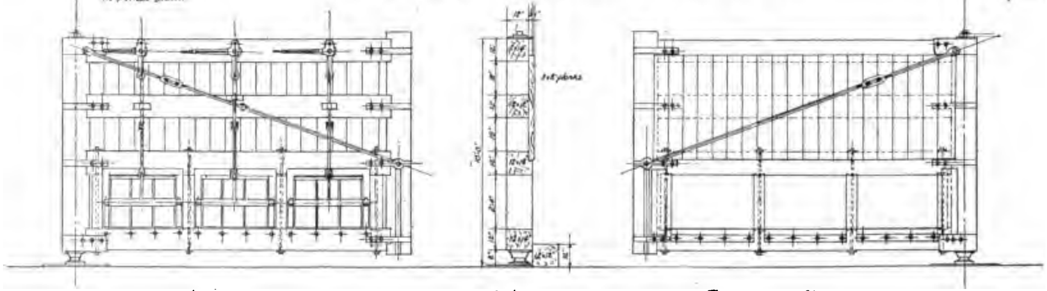
To accompany report of the Everglades Engineering Commission 1913.

4.

CAST IRON DETAILS FOR LOWER GATES.



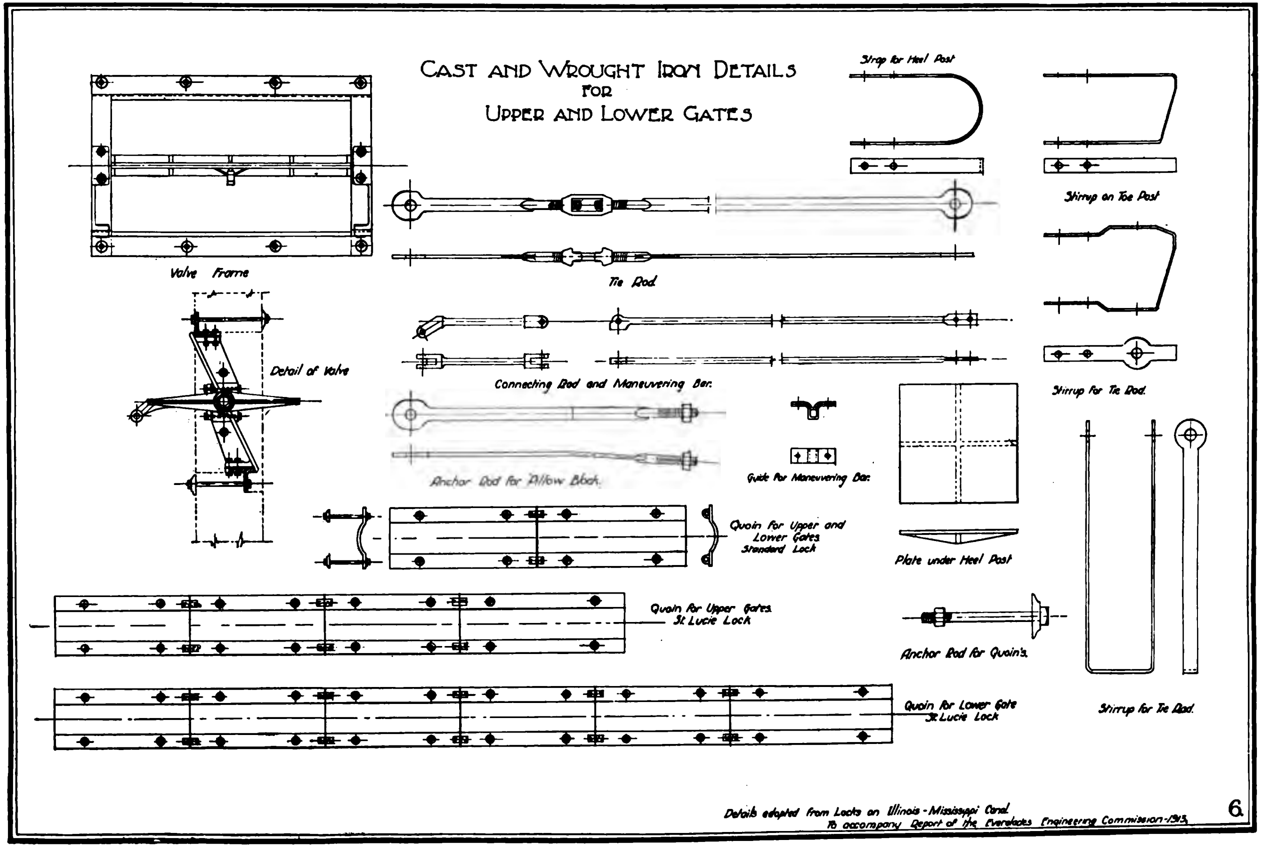
DETAIL OF LOWER GATES – STANDARD LOCKS



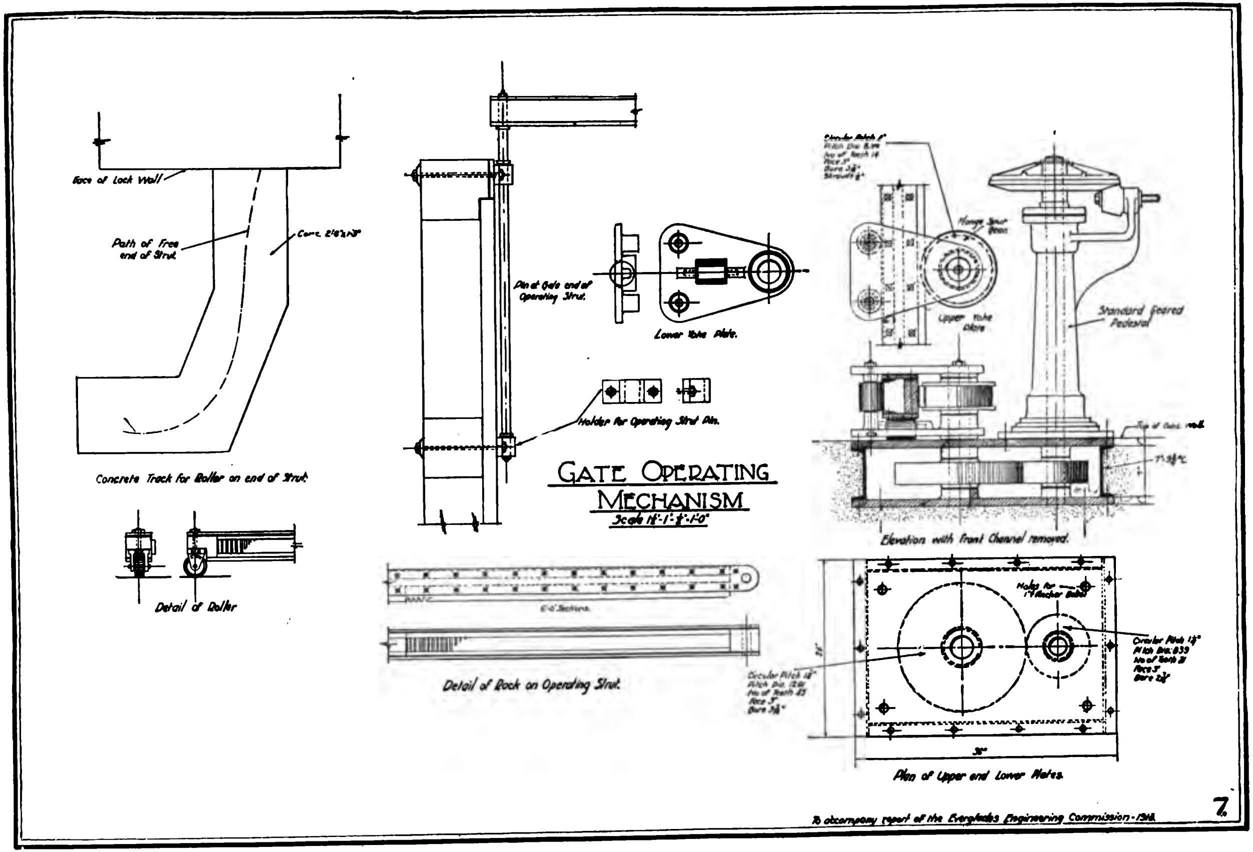
To accompany report of the Everglades Engineering Commission-1913.

5.

CAST AND WROUGHT IRON DETAILS FOR UPPER AND LOWER GATES


Strap for Heel Post
Stirrup on Toe Post
Valve Frame
Tie Rod
Detail of Valve
Connecting Rod and Maneuvering Bar.
Stirrup for Tie Rod.
Anchor Rod for Pillow Block.
Guide for Maneuvering Bar.
Quoin for Upper and Lower Gates Standard Lock
Plate under Heel Post
Quoin for Upper Gates St. Lucie Lock
Anchor Rod for Quoins.
Quoin for Lower Gate St. Lucie Lock
Stirrup for Tie Rod.
6.

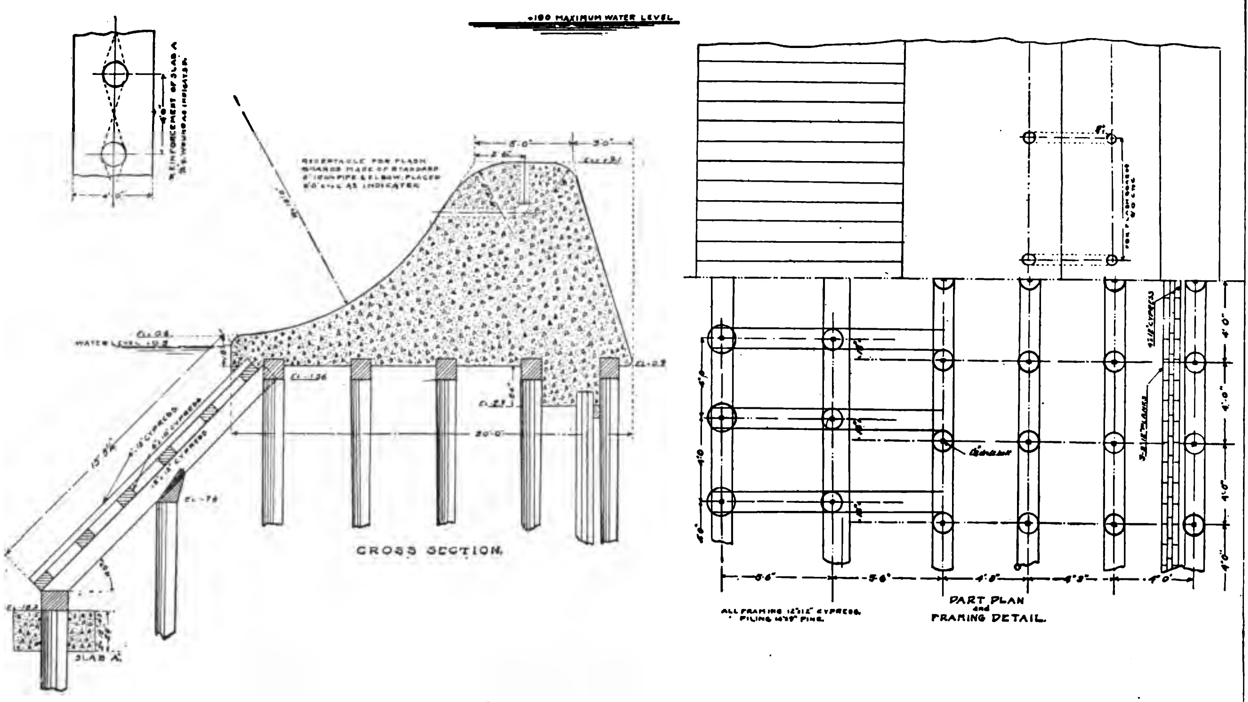
Details adapted from Locks on Illinois-Mississippi Canal.
To accompany Report of the Everglades Engineering Commission-1913.



GATE OPERATING MECHANISM

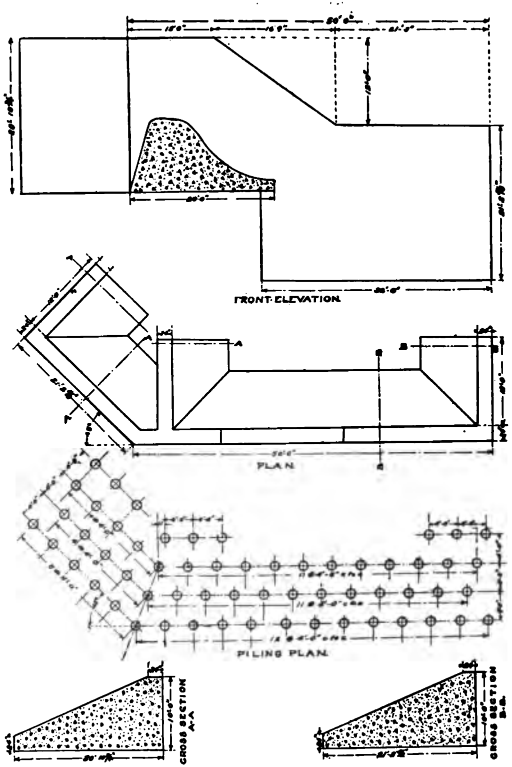
Scale 1½"-1' ⅜"-1'0"

To accompany report of the Everglades Engineering Commission - 1913.

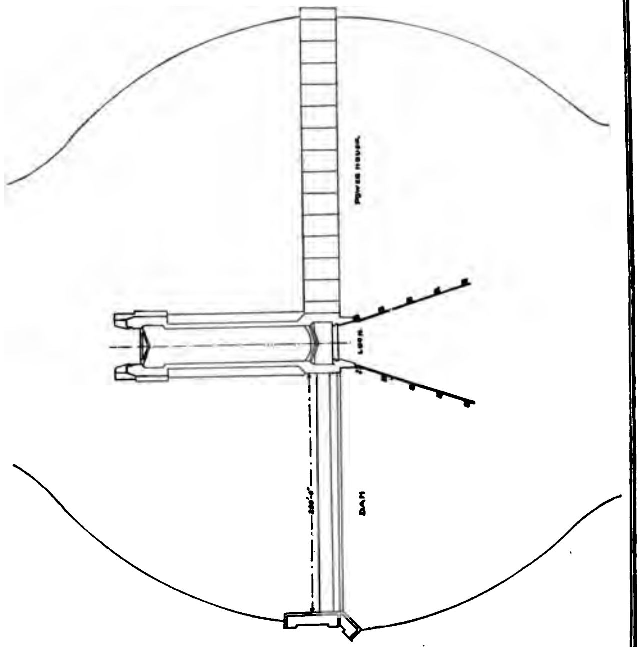


DAM AT ST LUCIE RIVER - OKEECHOBEE CANAL

To accompany report of the Everglades Engineering Commission 1913



BUTTRESS AT DAM
ST LUCIE RIVER - OKEECHOBEE CANAL



GENERAL PLAN OF PROPOSED INSTALLATION
ST LUCIE RIVER - LAKE OKEECHOBEE CANAL.

APPENDIX A.

MAPS AND SURVEYS USED IN COMPILATION OF FLORIDA EVERGLADES ENGINEERING COMMISSION.

U. S. Department of the Interior. General Land Office. State of Florida. 1911. Scale, 1 inch=12 miles.

U. S. Department of the Interior. Geological Survey. State of Florida. 1908. Scale, 1 inch=16 miles.

Map of Lake Okechobee, Florida. 1913. Scale, 1 inch=1 mile.

U. S. Post Office Department. Post-route map of the State of Florida. 1913. Scale, 1 inch=10 miles.

U. S. Department of Agriculture. Office of Experiment Stations. Map of portion of Florida, showing proposed drainage area. 1908. Scale, 1 inch=10 miles.

Proposed plan for draining the Florida Everglades. 1908. Scale, 1 inch=9 miles.

U. S. Treasury Department. Coast and Geodetic Survey. Charts 162 to 167, inclusive. Charts 172 to 178, inclusive. Scale, 1 inch=80,000 inches.

Topographic Reconnoissance Sheet, No. 2334.

U. S. War Department. Corps of Engineers, U. S. Army. Survey Lake Okeechobee. and Caloosahatchee River. 1911. 21 sheets. Drainage map Kissimmee and Caloosahatchee Rivers and Lake Okeechobee. 1909–1911. Scale, 1 inch=5 miles.

Map of Kissimmee Waterway, description of bench marks thereon.

U. S. War Department. Bureau of Topographical Engineers. Map of the State of Florida, compiled 1846. Scale, 1 inch=12 miles.

Drainage board, State of Florida. Plat of Okeechobee. Lake Worth Canal Survey. 1911. Scale, 1 inch=6 miles. Map of Everglades Drainage District. 1911. Scale, 1 inch=6 miles. Map of Everglades Drainage District. 1913. 1 inch=6 miles. Map to accompany Amended Instructions for Surveying Everglades Land. 1912. Scale, 1 inch=6 miles. Map showing Drainage Zones. 1913. Scale, 1 inch=6 miles. Map showing location of Snake Creek Canal. Scale, 6 inches=1 mile. Map showing location of Snapper Creek Canal. Scale, 6 inches=1 mile. Map of Territory from Lake Okechobee to Atlantic Ocean. 1913. Scale, 1 inch=1 mile.

State of Florida, Department of Agriculture. New Sectional Map of Florida. 1912. Scale, 1 inch=10 miles.

Florida East Coast Railway, Key West Extension. Everglades west of track and south of Detroit. 1911. Scale, 1 inch=2,000 feet.

Land Department, Peninsula of Florida and Adjacent Islands. Scale, 1 inch=14 miles. Location Survey through Dade and Monroe Counties, Miami to Cape Sable. 1903. Scale, 1 inch=10,000 feet. Route of Exploratory Party between Biscayne, Pinelands, and Tayton River. 1903. Scale, 1 inch=5,000 feet. Map of Cape Sable Country, W. J. Krome. Scale, 1 inch=1 mile. Map of Preliminary Line from Miami to West Line of Dade County in Everglades. Scale, 1 inch=1 mile.

Frederick and Butler, Miami, Fla. Map of Dade and Lee, also parts of Monroe, De Soto, and Manatee Counties. (Copyrighted.) 1909. Scale, 1 inch=3 miles.

Alfred Newlands, C. E. Map of Portion of the State of Florida showing Drainage District. Scale, 1 inch=10,000 feet.

J. M. Kramer, Chief Engineer. Map of Hicpochee and Okeechobee Sugar Lands. Dade and De Soto Counties. 1891. Scale, 1 inch=60 chains.

Palm Beach County, east side. Scale, 1 inch=2 miles.

Map of Big Cypress Swamp. Scale, 1 inch=2 miles.

APPENDIX B.

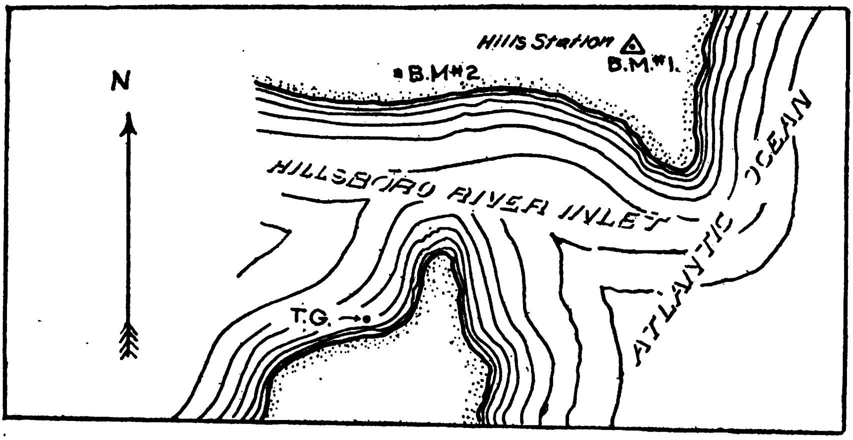
TIDE GAUGES, ATLANTIC OCEAN AND GULF OF MEXICO, COAST AND GEODETIC SURVEY.

HILLSBORO INLET, HILLSBORO RIVER, FLA.

[Lat. 26° 15′ N.; long. 80° 05′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

A plain staff gauge was set up in Hillsboro Inlet on the south side of Hillsboro River, east coast of Florida. Tides were observed between December 28, 1883, and February 8, 1884, by party of Assistant B. A. Colonna.



Bench mark 1 is the top of the coquina stone marking the triangulation station Hills, which corresponds to a reading of 17.72 feet on tide staff.

Bench mark 2 is a galvanized-iron spike driven to the head in the east side of a coconut tree growing at the water's edge on north side of Hillsboro Inlet, some 50 meters west of Hills triangulation station. Bench mark 2 corresponds to a reading of 9.03 feet on tide staff.

Tide planes.	Readings on staff of 1883.	Elevation bench marks above tide planes.	
		Bench mark 1.	Bench mark 2.
	Feet.	*Feet.*	*Feet.*
Highest tide observed	3.70	14.02	5.33
Mean of 49 high waters	3.09	14.63	5.94
Mean half-tide level	1.92	15.80	7.11
Mean of 54 low waters	.75	16.97	8.28
Lowest tide observed	.00	17.72	9.03
Mean range of tide	2.34	....	....

MIAMI ENTRANCE (NEW CUT), BISCAYNE BAY, FLA.

[Lat. 25° 46′ N.; long. 80° 08′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS 6, 7, 8, 9, 10, 11, AND 12.

[Bench marks 1 to 5 on separate sheet.]

Bench mark 6, established by United States engineers and recovered by Assistant W. C. Hodgkins in 1913, is a nail in the top of a concrete monument about 185 feet westerly from west end of North Jetty and almost in line with same.

Bench mark 7, established by United States engineers and recovered by Assistant W. C. Hodgkins in 1912, is a nail in the top of another concrete monument about 255 feet westerly from west end of North Jetty and almost in line with same.

Bench mark 8, established by Assistant W. C. Hodgkins in 1913, was a temporary one, the head of a large wire nail driven flush with the surface of an old 12 by 12 inch timber about 30 feet long, partly embedded in the sand, 26 paces to the westward of the tide gage. Three other nails form a rather large triangle about the bench mark.

Bench mark 9, established by Assistant W. C. Hodgkins in 1913, is the highest point of a large angular piece of rock at about high-water mark, at the foot of the south slope of the north jetty, abreast of the tide gage.

Bench mark 10, established by Assistant W. C. Hodgkins in 1913, is the top of a large piece of rock, about the middle line of north jetty and 17 paces eastward from bench mark 9. There is a 2-inch drill hole in the sloping northern surface of the rock about 2 feet north of the bench mark, which is the highest point of the rock.

Bench mark 11, established by Assistant W. C. Hodgkins in 1913, is the highest point of the south end of the large and rather flat-topped rock, 3 paces eastward of bench mark 10 and a little to the north of the middle line of the jetty.

Bench mark 12, established by Assistant W. C. Hodgkins in 1913, is the highest part of the sharp southwest point of a large brownish rock, a little to the southward of the middle line of the jetty and about 5½ paces to the eastward of bench mark 11. A very distinct band of feldspar crystals runs across the middle of the sloping northern face of the rock.

Tide planes.	Elevations of bench marks above tide planes.						
	Bench mark 6.	Bench mark 7.	Bench mark 8.	Bench mark 9.	Bench mark 10.	Bench mark 11.	Bench mark 12.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Highest tide observed	2.88	3.14	2.24	−0.04	1.41	1.04	0.66
Mean high water	4.80	5.06	4.16	1.88	3.33	2.96	2.60
Mean tide level	5.89	6.15	5.25	2.97	4.42	4.05	3.69
Mean low water	6.98	7.24	6.34	4.06	5.51	5.14	4.78
Lowest tide observed	7.88	8.14	7.24	4.96	6.41	6.04	5.68
Zero of tide staff	6.88	7.14	6.24	2.96	5.41	5.04	4.68

Table is based upon 392 high waters and 394 low waters.

MIAMI ENTRANCE (NEW CUT), BISCAYNE BAY, FLA.

[Lat. 25° 46′ N.; long. 80° 08′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

Tide gauge No. 1 was a box gauge, with an iron float pipe, and light movable rod on float, located near shore end of North Jetty. Tide gauge No. 2, was a plain staff just inside the cut, on east side of Key Biscayne Bay, opposite Miami. The zeros of these gauges were the same, and correspond to mean low water as established by E. B. Thompson, assistant United States engineer. Tides were observed between June 22, 1908, and June 30, 1909.

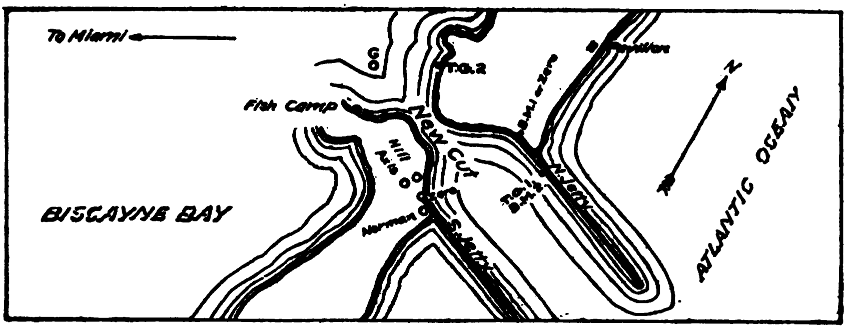
DESCRIPTIONS OF BENCH MARKS FROM RECORD LOANED BY UNITED STATES ENGINEERS.

Bench mark 1 is top of a 1¼-inch pipe driven in North Jetty at its western or shore end. It was known as zero of North Jetty and corresponds to reading 5.385 feet on gauge.

Bench mark 2 is the top of iron flange of float pipe of gauge 1 and corresponds to a reading of 5.287 feet on gauge.

Bench mark 3 is a notch cut in Mangrove at the New Cut and corresponds to a reading of 4.150 feet on either gauge.

Bench mark 4 is the top of a 1¼-inch pipe at Lums (7) Landing and corresponds to a reading of 3.890 feet on gauge.



Bench mark 5 is some nails on top of Pavilion wharf and corresponds to a reading of 3.645 feet on either gauge.

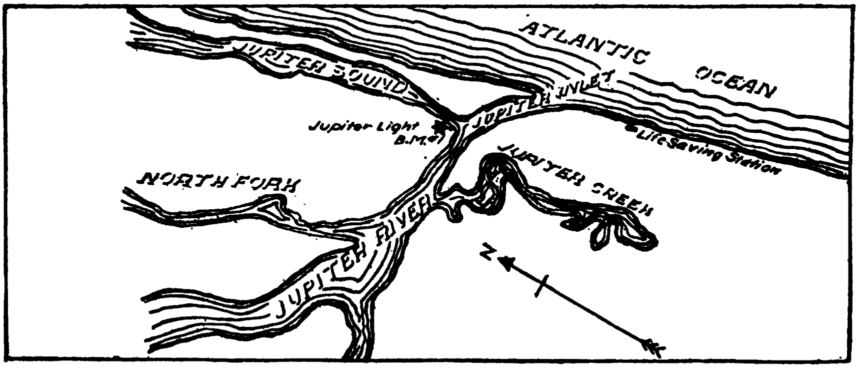
Tide planes.	Readings on elevation bench marks above tide planes.					
	Staff of No. 1.	Bench mark 1.	Bench mark 2.	Bench mark 3.	Bench mark 4.	Bench mark 5.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Highest tide observed	4.00	1.38	1.39	0.15	−0.11	−0.36
Mean 392 high waters	2.08	3.30	3.31	2.07	1.81	1.56
Mean half-tide level	0.99	4.39	4.40	3.15	2.90	2.65
Mean 394 low waters	−0.10	5.48	5.49	4.25	3.99	2.74
Lowest tide observed	−1.00	6.38	6.39	5.15	4.89	4.64
Mean range of tide	2.18	....	....	....	....	....

JUPITER LIGHTHOUSE, FLORIDA.

[Lat. 26° 57′ N.; long. 80° 05′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden tide staff was nailed to a pile of the wharf at Jupiter Lighthouse. Jupiter Inlet is very uncertain as to its closing or being open, and the entrance is about as changeable as it can be, no two tides leaving the bar the same. Tides were observed between April 26 and May 12, 1883, by party of Lieut. H. B. Mansfield, United States Navy, and by party of Assistant B. A. Colonna, between March 20 and 23, 1884.



Bench mark 1 is the western end of cast-iron doorsill of lighthouse doorway, and corresponds to 62.85 feet on staff.

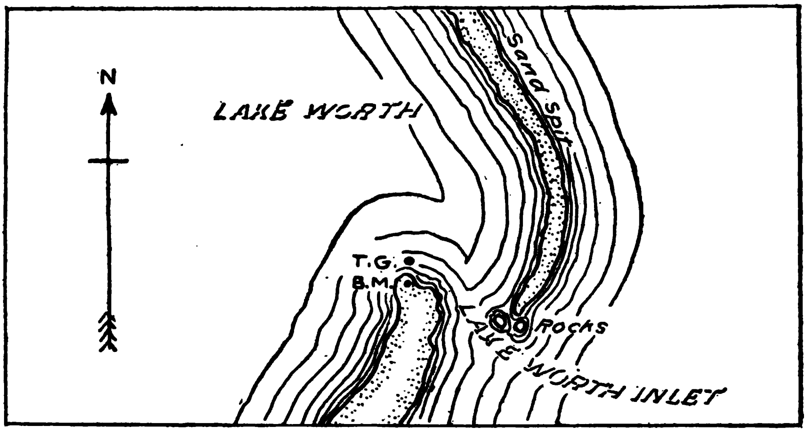
Tide planes.	Readings on staff of 1883.	Elevations of bench mark above tide planes.
	Feet.	*Feet.*
Highest tide observed	5.90	56.95
Mean 30 high waters	5.21	57.64
Mean half-tide level	4.79	58.06
Mean 29 low waters	4.37	58.48
Lowest tide observed	4.00	58.85
Mean range of tide	.84	....

LAKE WORTH INLET, FLA.

[Lat. 26° 49′ N.; long. 80° 02′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden tide staff was erected on the southwest side of Lake Worth Inlet, Fla. Tides were observed between February 22 and March 6, 1884, by party of Assistant B. A. Colonna.



Bench mark 1 is the head of a nail driven all the way into a bay stump on south side of Lake Worth Inlet. It corresponds to a reading of 5.02 feet on tide gauge.

Tide planes.	Readings on staff of 1884.	Elevations of bench mark above tide planes.
	Feet.	*Feet.*
Highest tide observed	4.40	0.62
Mean of 9 high waters	3.89	1.13
Mean half-tide level	3.36	1.66
Mean of 13 low waters	2.83	2.19
Lowest tide observed	2.54	2.48
Mean range of tide	1.06	....

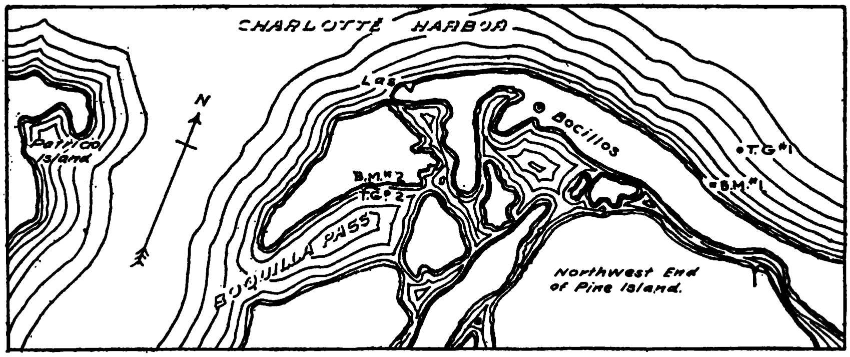
PINE ISLAND, CHARLOTTE HARBOR, FLA.

[Lat. 26° 42′ N.; long. 82° 09′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

Plain wooden tide staves were set up at the two places indicated in sketch on the northern end of Pine Island. Tides were observed by party of Lieut. Commander

C. M. Chester, United States Navy, and assistant United States Coast and Geodetic Survey on staff 1, from February 1 to April 13, 1880, and on staff 2 from March 7 to May 15, 1880.



Bench mark 1 consists of 4 copper tacks driven thus . . . . into a blazed surface on the northern side of a large palm tree, corresponding to a reading of 11.12 feet on gauge 1, or 9.35 feet on guage 2.

Bench mark 2 consists of 6 iron nails driven in a large fig tree near Mr. Allen's house, and about 20 paces from beginning of wharf in Boquilla Pass, northwest part of Pine Island. It corresponds to a reading of 10.32 feet on gauge 2.

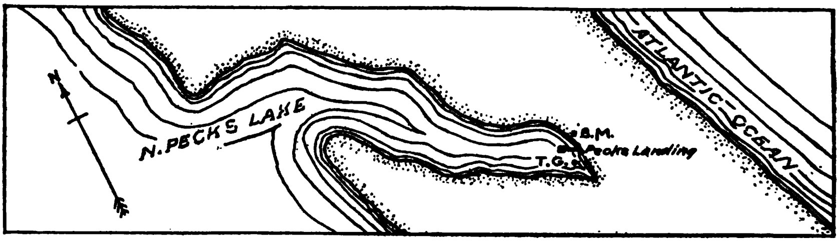
Tide planes.	Readings on staff 2, 1880.	Elevation of bench marks above tide planes.	
		Bench mark 1.	Bench mark 2.
	Feet.	*Feet.*	*Feet.*
Highest tide observed	4.30	5.05	6.02
Mean 97 high waters	3.31	6.04	7.01
Mean half-tide level	2.74	6.61	7.58
Mean 82 low waters	2.17	7.18	8.15
Lowest tide observed	1.38	7.97	8.94
Mean range of tides	1.14		

PECKS LANDING, PECKS LAKE, FLA.

[Lat. 27° 07′ N.; long. 80° 08′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden tide staff, was set up about 12 feet from shore at the end of a small arm extending eastward from Pecks Lake, about half a mile north of the north end of South Jupiters Narrows. Tides were observed between June 9, 1883, and February 18, 1884, by party of Assistant B. A. Colonna.



Bench mark consists of a coquina stone 18 inches long and 6 inches square, resting on an iron signal head which is buried so as to leave about an inch of the top of the stone above ground. The bench mark is right at the landing, on north side of curve, and about 12 feet from the water line, and 80 feet north of tide gauge. It corresponds to a reading of 2.40 feet on tide gauge.

Tide planes.	On staff.	Below bench mark.
	Feet.	*Feet.*
Highest water observed	4.10	−1.70
Mean water level	1.83	.57
Lowest water observed	.40	2.00

There is practically no periodic tide. Rise and fall of water depends chiefly upon meteorological conditions.

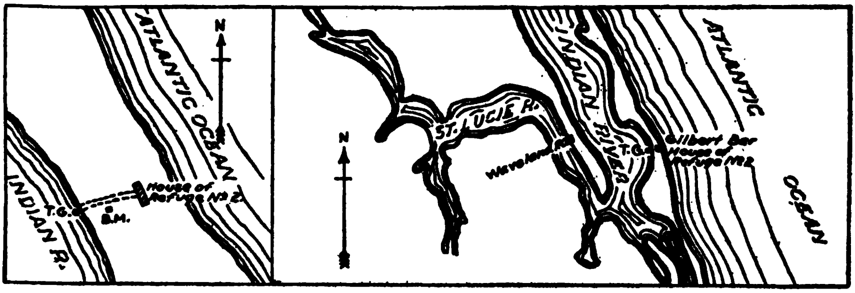
The above table is based upon 762 staff readings.

GILBERT BAR, INDIAN RIVER, FLA.

[Lat. 27° 11′ N.; long. 80° 10′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden tide staff was fastened to the end of the wharf belonging to House of Refuge No. 2, at Gilbert Bar, on the coast shore of Indian River. Tides were observed between May 22 and June 11, 1883, by party of Assistant B. A. Colonna.



Bench mark is a brass nail in top of a coquina stone about 4 feet south of trail leading from wharf to house of refuge No. 2, and about 30 meters from the house. The stone is 31 inches long and 6 inches square, and rests in a hole 6 inches deep cut in the solid rock 20 inches below the surface of the ground. The top of the stone was cut square. In 1907, Assistant I. Winston found this stone with one-half of top broken off, but not destroyed. He had it placed in position, and a nail keg was placed around the stone and filled with cement and sand for the purpose of preserving it. Bench mark corresponds to a reading of 10,000 feet on tide staff.

Tide planes.	On staff.	Below bench mark.
	Feet.	*Feet.*
Highest water observed	2.00	8.00
Mean water level	1.13	8.87
Lowest water observed	.65	9.35

There is practically no periodic tide. Rise and fall of water depend chiefly upon meteorological conditions.

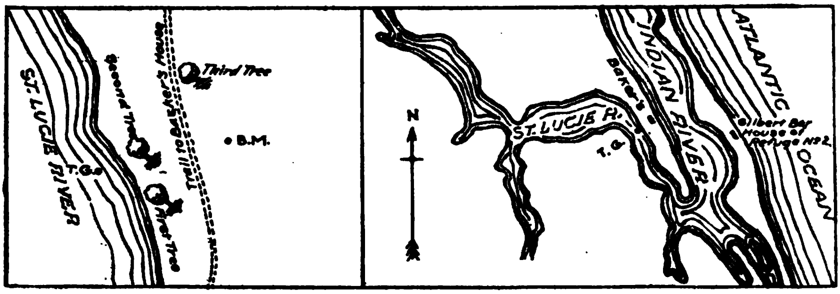
The above table is based upon 40 staff readings.

WAVELAND POST OFFICE, ST. LUCIE RIVER, FLA.

[Lat. 27° 11′ N.; long. 80° 12′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden staff was nailed to a post driven in the river bed on the east shore of St. Lucie River, about 2 miles above the mouth and at the end of trail leading over from Dr. W. H. Baker's house on Indian River. Tides were observed between May 22 and June 9, 1883, by party of Assistant B. A. Colonna.



Bench mark is a nail in top of a coquina stone, about 50 feet back from St. Lucie River, just at the foot of a high bank and close to the trail coming over from Dr. Baker's house. The stone is 30.7 inches long; the top was cut square and projects about 4 inches above ground. The stone rests on an iron signal or tripod head. Triangles were cut on three palmetto trees, bearing from bench mark as follows: First tree, 249°, distant about 20 feet; second tree, 255° in line to gauge; and third tree, 333°, distant 26 feet. Bench mark corresponds to reading of 9.90 feet on tide staff.

Tide planes.	On staff.	Below bench mark.
	Feet.	*Feet.*
Highest water observed	1.60	8.30
Mean water level	.96	8.94
Lowest water observed	.50	9.40

There is practically no periodic tide. Rise and fall of water depend chiefly upon meteorological conditions.

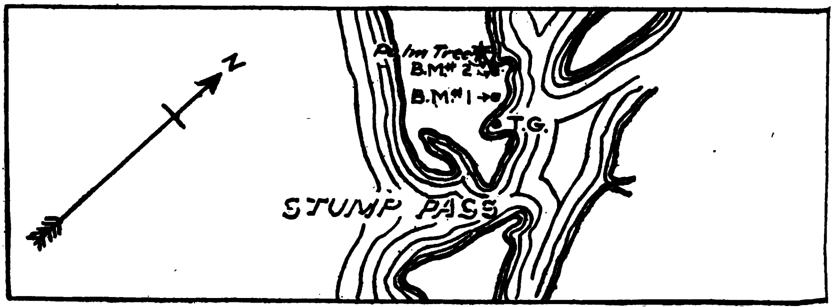
The above table is based upon 34 staff readings.

STUMP PASS, LEMON BAY, FLA.

[Lat. 26° 55′ N.; long. 82° 21′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

A plain staff gauge was set in first cove on the north side after entering Stump Pass. Tides were observed between May 23 and June 4, 1883, by party of Assistant J. Hergesheimer and between May 5 and 7, 1884, by party of Lieut. H. B. Mansfield.



Bench mark 1 is the top of a stone with U. S. B. M. 1880 cut in the top. It corresponds to a reading of 4.65 feet on staff of 1883.

Bench mark 2 is the top horizontal line of a triangle cut in a palm tree. It corresponds to a reading of 7.998 feet on staff of 1883.

Tide planes.	Readings on staff of 1883.	Elevation of bench marks above tide planes.	
		Bench mark 1.	Bench mark 2.
	Feet.	*Feet.*	*Feet.*
Highest tide observed	3.40	1.25	4.60
Mean high water	3.00	1.65	5.00
Mean half-tide level	2.12	2.53	5.88
Mean low water	1.24	3.41	6.76
Lowest tide observed	.80	3.85	7.20
Mean range of tides	1.76		

The above table is based upon 11 observed high waters and 6 observed low waters.

PUNTA RASSA, FLA.

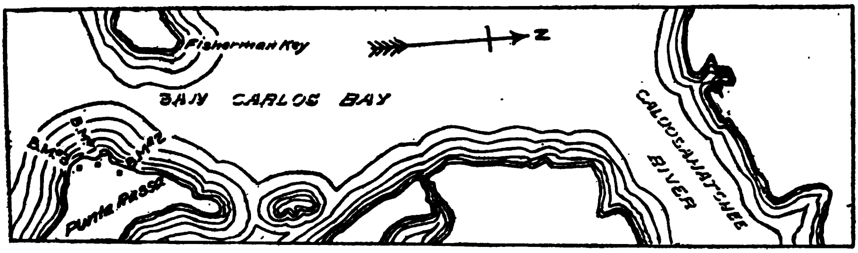
[Lat. 26° 29′ N.; long. 81° 59′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

Plain wooden tide staffs were set up on the wharf in front of Government building at Punta Rassa, Fla., as follows:

1866, June 21 to August 15, by Asst. W. S. Edwards.
1867, March 28 to April 29, by Asst. W. S. Edwards.
1884, May 12 to May 29, by Asst. H. B. Mansfield, United States Navy.
1885, May 7 to May 14, by Assst. E. D. F. Healed, United States Navy.

The same staff was used in 1866 and 1867, and another staff was used in 1884 and 1885.



Bench mark 1 originally consisted of 5 nails driven into the southwest corner foundation post of the Parker House in the form of a cross thus ⁛ the center nail being 12 feet above zero of tide staff of 1866–67. Later, this mark was changed by tacking a strip of sheet copper on the post, the upper edge of which was the same height as the central nail, that is, 12 feet on staff of 1866–67, and 10.68 feet on staff 1884–85.

Bench mark 2 is the central one of 7 copper nails driven thus ∵ in the form of an inverted triangle, into the southwest support of the pyramidal house near the wharf, about 2 feet above the ground. It corresponds to a reading of 10.22 feet on staff of 1866–67 and 8.90 feet on staff of 1884–85.

Bench mark 3 is the flat top of a square brick column, about 3 feet high, 500 meters south of gauge and 50 meters east of telegraph station, is probably a triangulation station, and corresponds to a reading of 12.12 feet on staff of 1866–67 and 10.80 feet on staff of 1884–85.

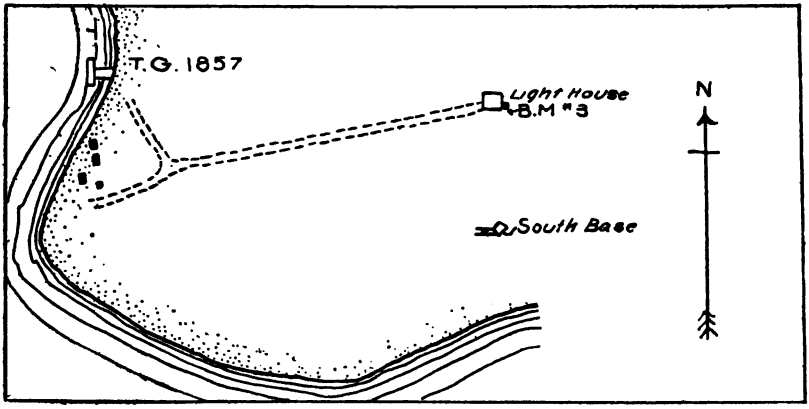
Tide planes.	Readings on staff of 1884-85.	Elevation bench marks above tide planes.		
		Bench mark 1.	Bench mark 2.	Bench mark 3.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Highest tide observed	5.68	5.00	3.22	5.12
Mean of 96 high waters	5.06	5.62	3.84	5.74
Mean half-tide level	4.20	6.48	4.70	6.60
Mean of 100 low waters	3.34	7.34	5.56	7.46
Lowest tide observed	2.05	8.63	6.85	8.75
Mean range of tide	1.72	....	....	....

CAPE FLORIDA, KEY BISCAYNE, FLA.

[Lat. 25° 40′ N.; long. 80° 10′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

A self-registering tide gauge was set up on piles on the inside shore, about 5° N. of W. from the lighthouse. A fixed staff was used for the purpose of comparison. Observations made in 1854, 1855, 1857, and 1858.



Bench mark 1 destroyed.

Bench mark 2 destroyed.

Bench mark 3 is the north end of outer edge of stone sill of lighthouse and is 7.48 feet above zero of tide staff of 1857.

Bench mark 4 established by Assistant I. Winston in 1908 is a 6-inch iron pipe 4 feet long, buried 3 feet 6 inches in the ground. It was surrounded by a mass of cement and sand and brickbats and was filled with the same material except that pure cement was used on the inside at the top. A standard brass precise leveling bench mark was inserted in this cement so that the disk shows just above the surface. The disk is lettered U. S. C & G. S. $250 fine, etc. The upper surface of the disk at its center was used as the bench mark. An avenue of coconut palms extends west from the lighthouse to shore across the point of the cape and bench mark is on south side of avenue 50 meters west of lighthouse. Bench mark 4 corresponds to a reading of 6.46 feet on staff of 1857.

Bench mark 5 established by Assistant I. Winston in 1908. Forty meters from the lighthouse to southwest of top of a cylindrical cistern, built with top covered with a thick coat of cement, stands about 2 feet above the ground. The ruins of the keeper's houses are nearby and the cistern is uncovered. On one side the figures "1898" are roughly printed in the cement and the surface of the cement inside the top of the figure 9 was used as the bench mark. Bench mark 5 corresponds to a reading of 8.31 feet on staff of 1857.

Tide planes.	Readings on staff of 1857.	Elevations bench marks above tide planes.		
		Bench mark 3.	Bench mark 4.	Bench mark 5.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Highest tide observed	5.00	2.48	1.46	3.31
Mean high water	3.50	3.98	2.96	4.81
Mean tide level	2.74	4.74	3.72	5.57
Mean low water	1.98	5.50	4.48	6.33
Lowest tide observed	1.20	6.28	5.26	7.11
Mean range of tide	1.52	....	....	....

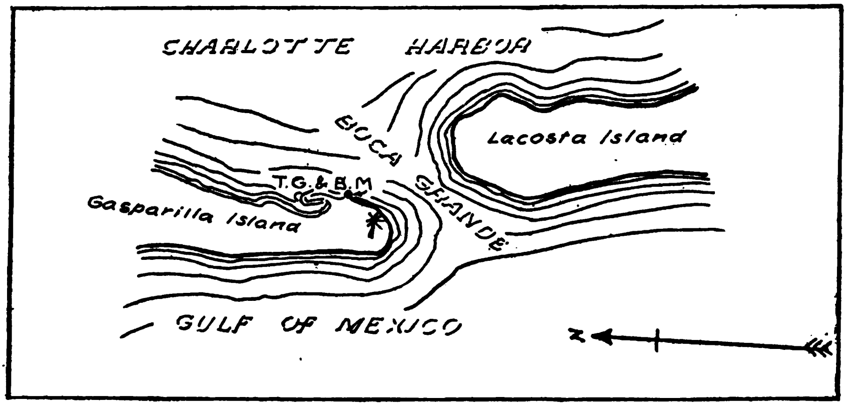
Table is based upon 930 high waters and 929 low waters.

GASPARILLA ISLAND, CHARLOTTE HARBOR, FLA.

[Lat. 26° 41′ N.; long. 80° 17′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain tide staff was set up inside of Boca Grande, on the southern end of Gasparilla Island, Charlotte Harbor, Fla. Tides were observed by party of Edward Cordell between April 10 and 30, 1863.



Bench mark is an iron spike in the center of a cross of copper nails driven into a mangrove stump about 3 feet above ground. The stump is at the edge of the woods, 5 paces from high water mark, and 444 meters NE. by E. 1/4 E. from Boca Grande Lighthouse. The bench mark corresponds to a reading of 6.40 feet on tide gauge.

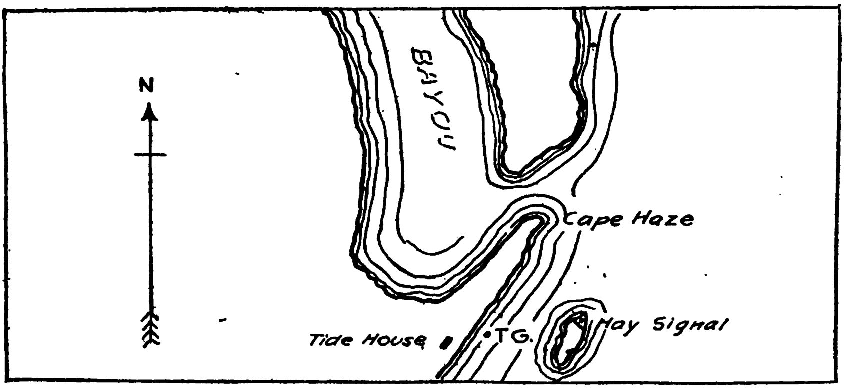
Tide planes.	Readings on staff of 1863.	Elevation of bench mark above tide planes.
	Feet.	*Feet.*
Highest tide observed	2.60	3.80
Mean of 31 high waters	2.43	3.97
Mean half-tide level	1.70	4.70
Mean of 31 low waters	.97	5.43
Lowest tide observed	.40	6.00
Mean range of tides	1.46	....

CAPE HAZE, CHARLOTTE HARBOR, FLA.

[Lat. 26° 47′ N.; long. 82° 09′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain staff gauge was secured by braces about 5 meters from shore of Cape Haze, about one-eighth mile due W. 1/2 S. from El Cabo or Hay signal. Tides were observed between March 17 and May 9, 1878, by party of J. M. Hawley.



Bench mark is a notch in a tarred pine scantling, 5¼ by 3½, driven in the shore line among the bushes and braced to a stout mangrove. It was marked by a band of white paint. It corresponds to a reading of 8 feet on tide gauge.

Tide planes.	Readings on staff of 1878.	Elevation of bench mark above tide planes.
	Feet.	*Feet.*
Highest tide observed	8.35	−0.35
Mean high water	6.67	1.33
Mean half-tide level	6.01	1.99
Mean low water	5.35	2.65
Lowest tide observed	4.45	3.55
Mean range of tides	1.32	....

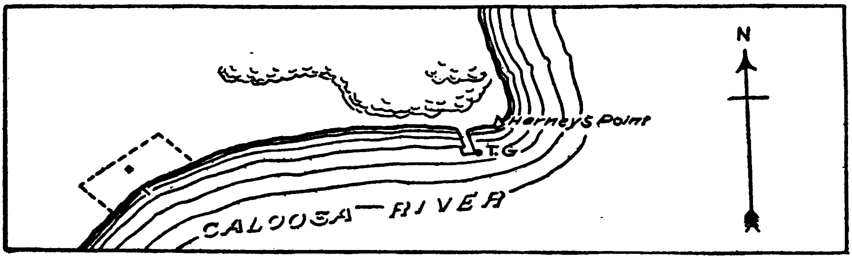
The above table is based upon 73 observed high waters and 73 observed low waters.

HARNEYS POINT, CALOOSA RIVER, FLA.

[Lat. 26° 33′ N.; long. 81° 56′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

Tide gauge was placed on southeast pile of wharf and tides were observed between April 14–28, 1893, by party of Assistant W. I. Vinal.



Bench mark 1 is a horizontal row of four wire nails and one galvanized nail, thus . . . . . in the third pile north from the southeast corner of Harneys Wharf, and corresponds to a reading of 6 feet on tide gauge.

Bench mark 2 is a horizontal row of three wire nails and one galvanized nail, thus . . . . in the second pile north from the southeast corner of Harneys Wharf and corresponds to a reading of 6 feet on tide gauge.

Bench mark 3 is a horizontal row of three galvanized nails, thus——in the pile at the southeast corner of Harneys Wharf and corresponds to a reading of 6 feet on gauge.

Bench mark 4 is a horizontal row of four wire, two galvanized, and one copper nails, thus . .   . .. in the second pile west of the southeast corner of Harneys Wharf and corresponds to a reading of 6 feet on tide gauge.

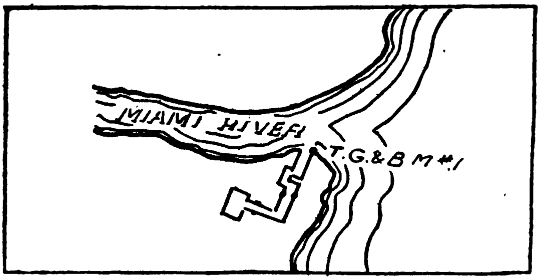
Tide plains.	Readings on staff of 1893.	Elevation of bench marks above tide plane bench marks.
	Feet.	*Feet.*
Highest tide observed	5.20	0.80
Mean 11 observed high waters	4.10	1.90
Mean half-tide level	3.72	2.28
Mean 13 observed low waters	3.34	2.66
Lowest tide observed	3.00	3.00
Mean range of tides	.76	....

MIAMI RIVER, KEY BISCAYNE BAY, FLA.

[Lat. 25° 46′ N.; long. 80° 12′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARK.

A plain wooden staff gauge was erected on the southern shore of the Miami River near its mouth. Observation by party of C. A. Bradbury, United States Navy, and assistant, Coast and Geodetic Survey, between March 23 and May 13, 1876.



Bench mark 1 consists of two galvanized iron spikes, driven into the coral rock at the tide gauge on a level with the 3-foot mark of the gauge.

Tide planes.	Readings on staff of 1876.	Elevations of bench mark above tide planes.
	Feet.	*Feet.*
Highest tide observed	2.75	0.25
Mean of 65 high waters	1.76	1.24
Mean half-tide level	1.23	1.77
Mean of 64 low waters	.70	2.30
Lowest tide observed	.20	2.80
Mean range of tide	1.06	....

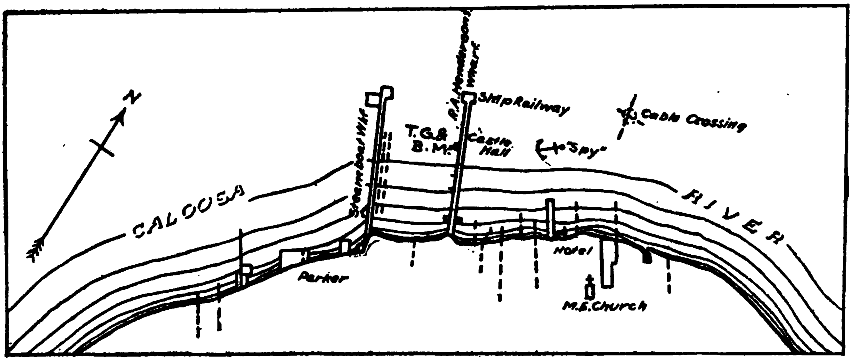
MYERS, CALOOSA RIVER, FLA.

[Lat. 26° 39′ N.; long. 81° 52′ W.]

DESCRIPTION OF TIDE GAUGE AND BENCH MARKS.

A plain staff gauge was attached to a pile in bathing tank under "Castle Hall," property of G. W. Kennison.

Tides were observed between April 1 and May 5, 1893, by party of Assistant W. I. Vinal.



Bench mark 1 consists of 4 galvanized nails driven in a pile supporting the tide staff. This is on south side of "Castle Hall" and is 2 meters from southwest corner. It corresponds to reading of 8 feet on gauge.

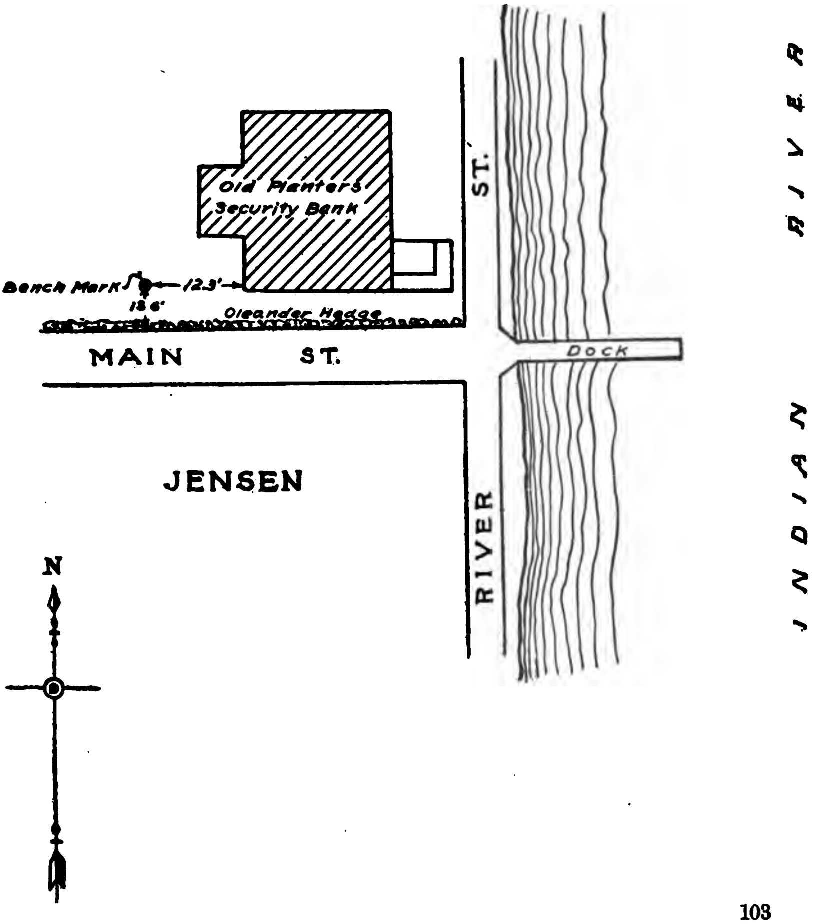
Bench mark 2 is the top of sill supporting platform inside of the bathing tank, and corresponds to reading of 5.20 feet on gauge.

Tide planes.	Readings on staff of 1893.	Elevation bench marks above tide planes.	
		Bench mark 1.	Bench mark 2.
	Feet.	*Feet.*	*Feet.*
Highest tide observed	5.50	2.50	−0.30
Mean 31 high waters	4.04	2.96	1.16
Mean tide level	2.62	4.38	1.58
Mean 22 low waters	3.20	4.80	2.00
Lowest tide observed	2.80	5.20	2.40
Zero of tide staff	.00	8.00	5.20
Mean range of tide	.83		

APPENDIX C.

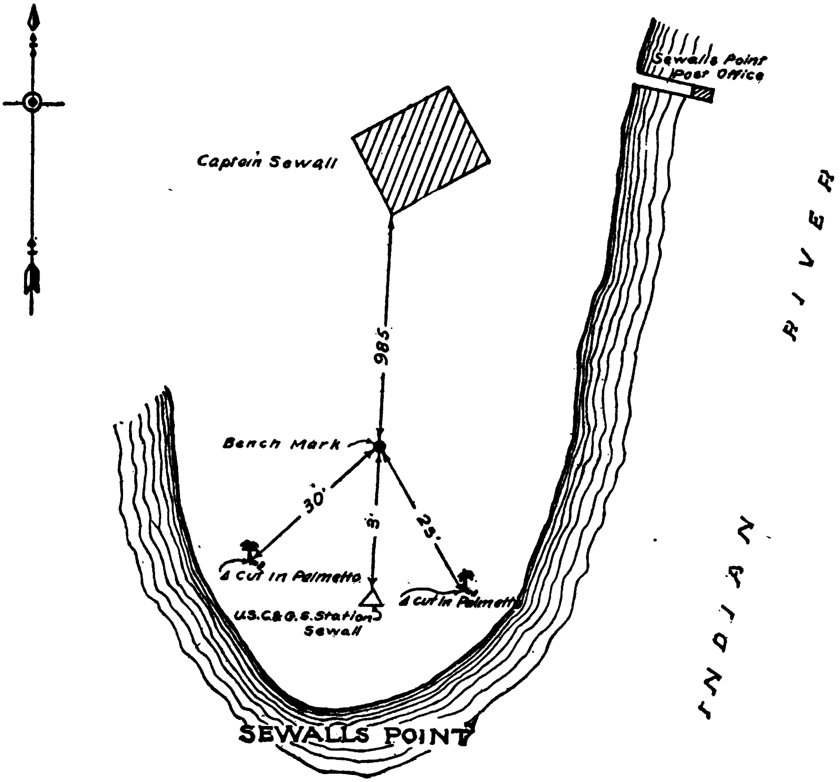
BENCH MARKS ON ATLANTIC COAST, FLORIDA INTRACOASTAL CANAL.

Place.—Indian River at Jensen, Fla.
Designation.—Florida Intracoastal bench mark No. 32
Elevation.—11.940 above mean low water, Fernandina
Description.—Situated 12.3 feet west of southwest corner of Old Planters Bank, and 13.6 feet north of north edge of sidewalk at Jensen, Fla. Consists of stovepipe filled with cement, with galvanized lag screw in top.

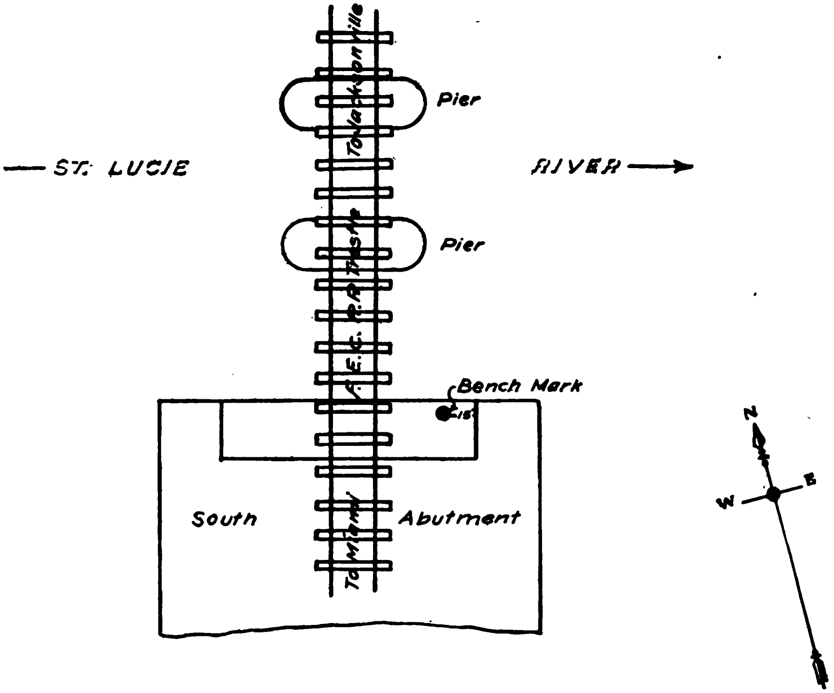


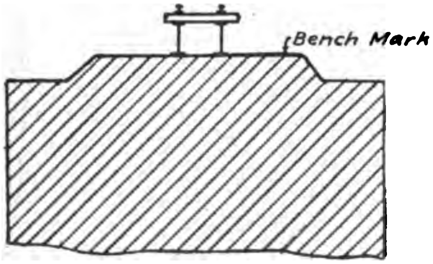
Place.—Sewalls Point, Fla.
Designation.—Florida Intracoastal bench mark No. 33.
Elevation.—36.541 above mean low water, Fernandina.

Description.—Situated 98.5 feet south of Sewall's residence, 3 feet north of center of United States Coast and Geodetic triangulation station "Sewall." Bench mark consists of stovepipe filled with cement, lag screw placed in center of top. Top 2 inches above ground.

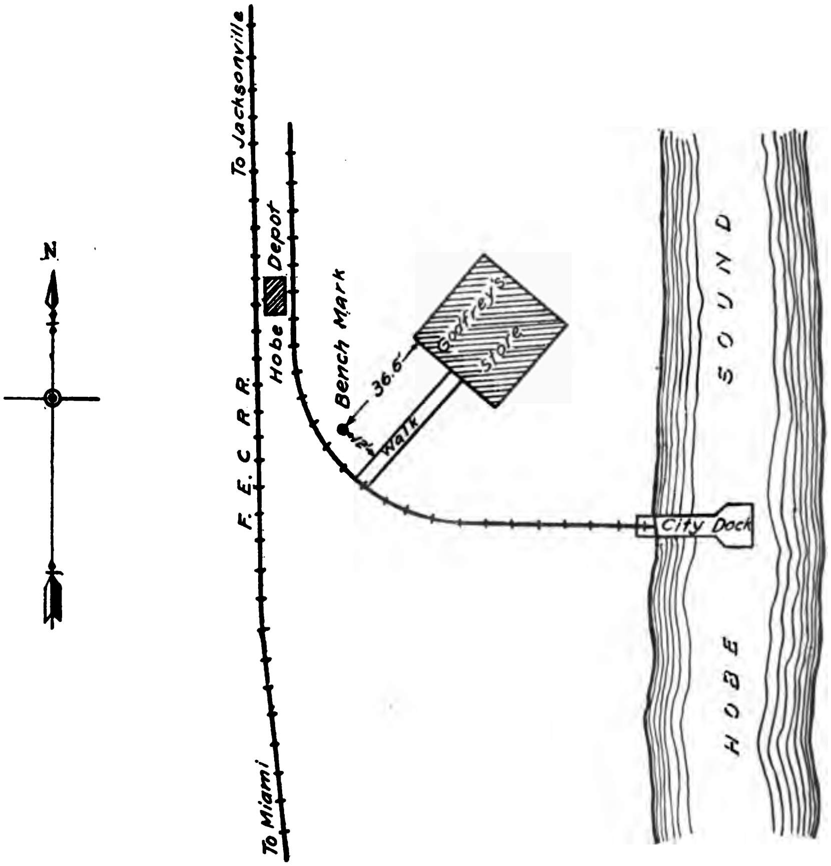


Place.—St. Lucie River at Stuart, Fla.
Designation.—Florida Intracoastal bench mark No. 34.
Elevation.—4.670 above mean low water, Fernandina.
Description.—Is on south abutment to Florida East Coast trestle over St. Lucie River, Stuart, Fla.

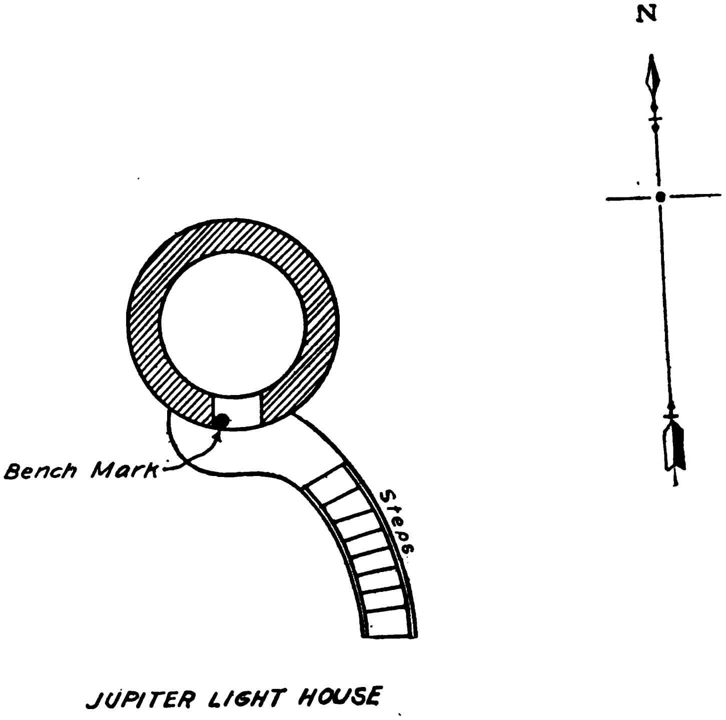




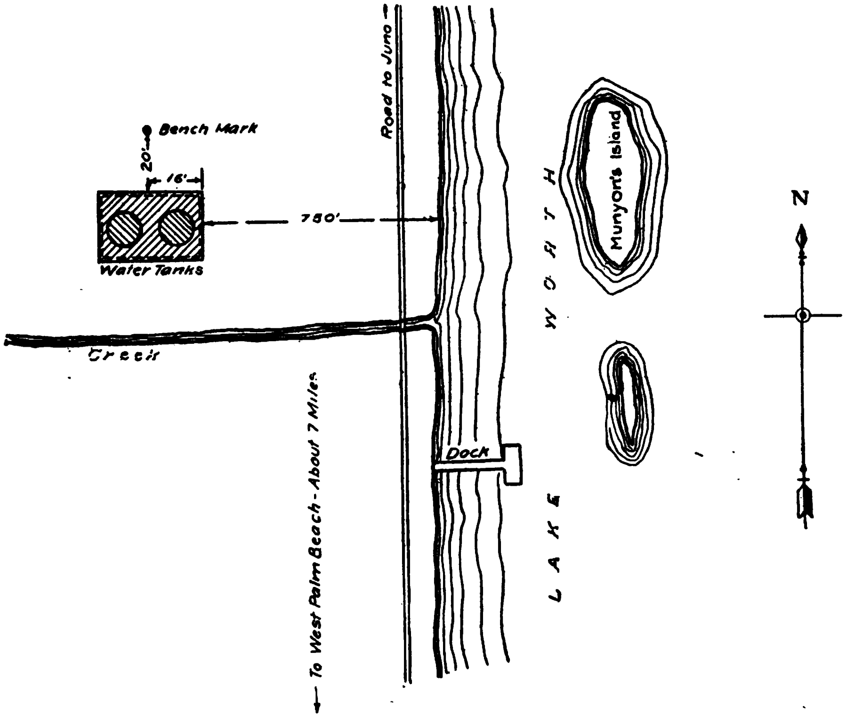
Place.—Hobe Sound, Fla.
Designation.—Florida Intracoastal bench mark No. 35.
Elevation.—7.763 above mean low water, Fernandina.
Description.—Situated at Hobe Sound, Fla., 36.6 feet south of southwest corner of Godfrey's store and 12 feet west of sidewalk leading into store. Bench mark consists of stovepipe filled with cement with lag screw in center of top. Top of bench mark is 1 inch from surface of ground.



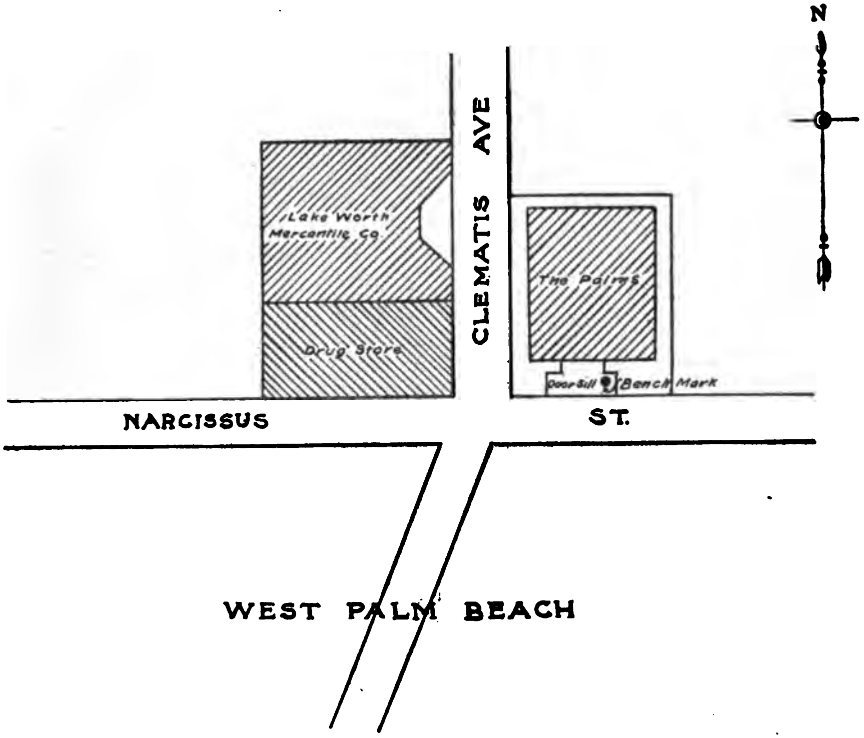
Place.—Jupiter Lighthouse, Fla.
Designation.—Florida intracoastal bench mark No. 36.
Elevation.—51.088 above mean low water, Fernandina.
Description.—Located on top of west end of iron doorsill to Jupiter Lighthouse.



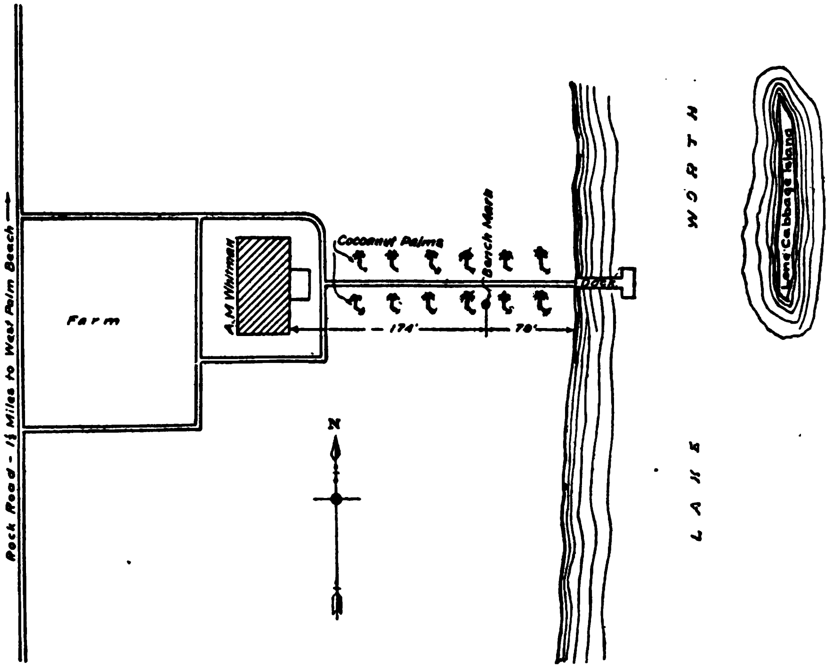
Place.—Lake Worth near Munyons Island.
Designation.—Florida intracoastal bench mark No. 37.
Elevation.—12.896 above mean low water Fernandina.
Description.—Situated 20 feet north of a point 16 feet west of east end of a rock foundation (for two water tanks) running east and west, situated on west shore of Lake Worth, almost due west of south point of Munyons Island, about 750 feet west of shore line. Bench mark is top of lag screw set in concrete monument made by placing concrete in stovepipe.



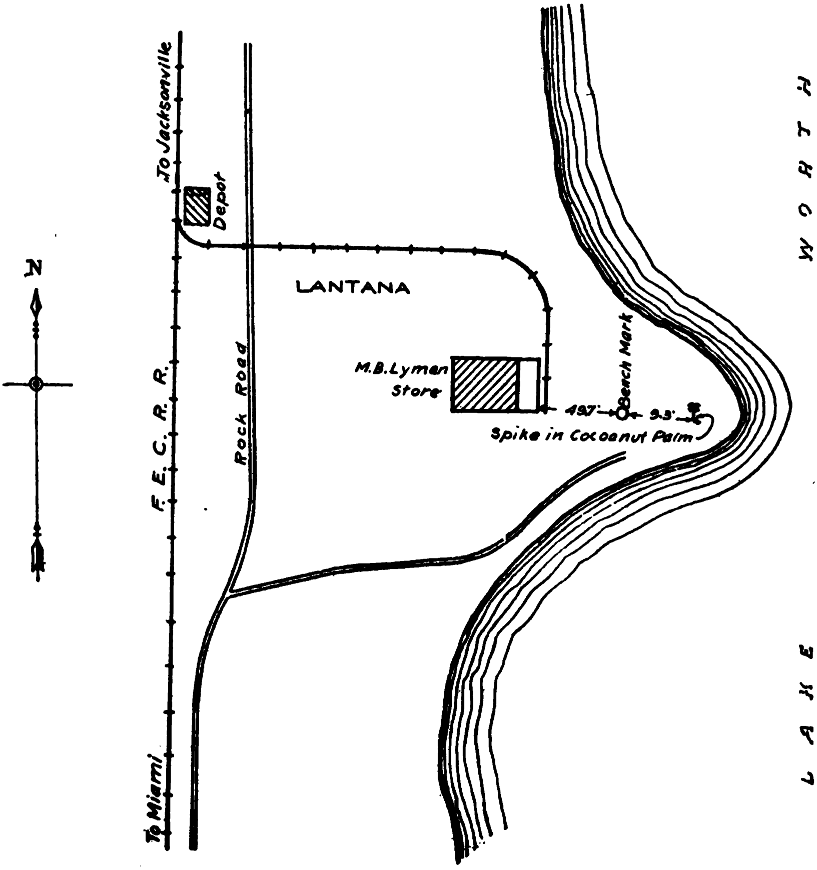
Place.—West Palm Beach, Fla.
Designation.—Florida intracoastal bench mark No. 38.
Elevation.—14.069 above mean low water, Fernandina.
Description.—Situated on the northeast corner of doorsill to east entrance to "The Palms."



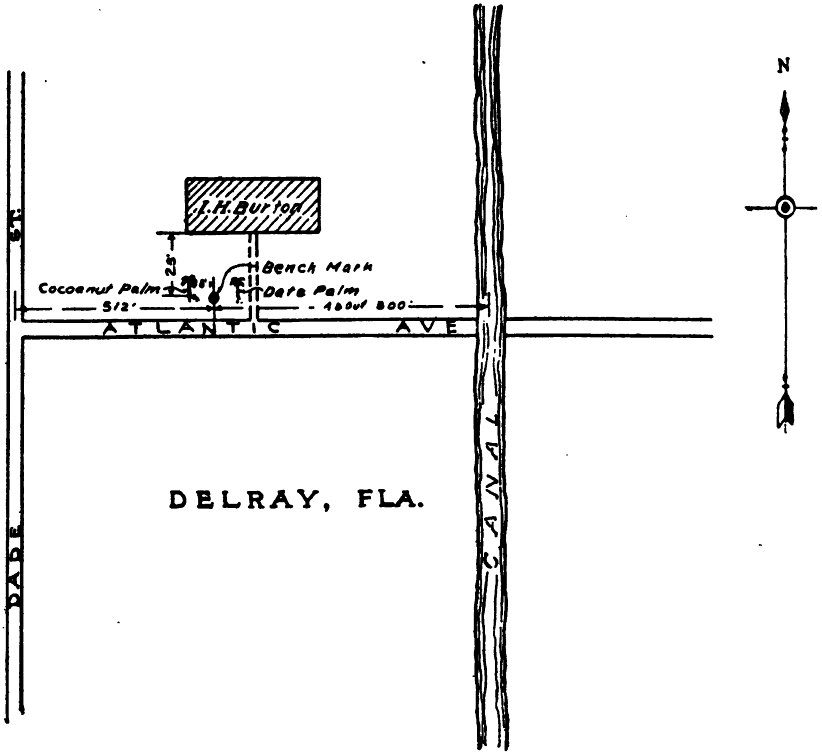
Place.—Lake Worth near Lone Cabbage Island.
Designation.—Florida intracoastal bench mark No. 39.
Elevation.—4.082 above mean low water, Fernandina.
Description.—Is tin pipe filled with cement and with galvanized lag screw slightly above cement. Located between second and third coconut plam from water, in south row of palms from water to Whitmans House on Lake Worth. Bench mark is 78 feet from water's edge.



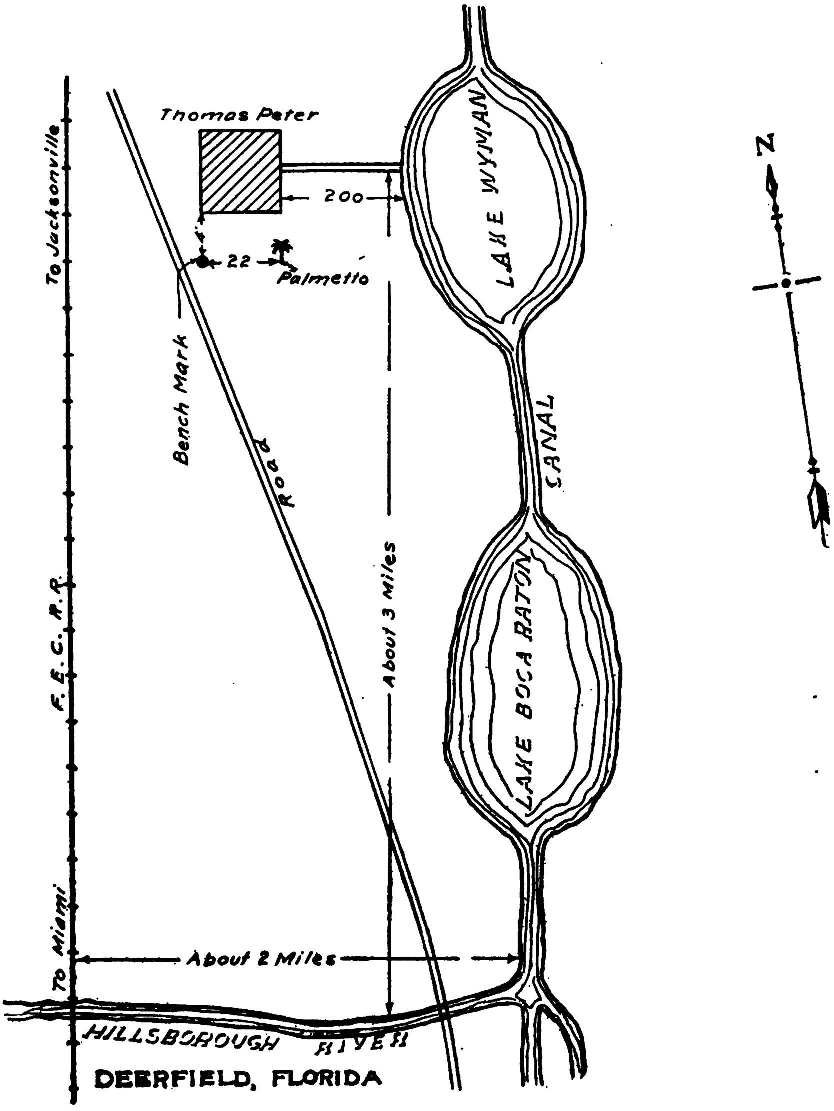
Place.—Lake Worth at Lantana, Fla.
Designation.—Florida intracoastal bench mark No. 40.
Elevation.—2.680 above mean low water, Fernandina.
Description.—Located at Lantana 49.7 feet a little southeast of southeast corner of M. B. Lyman's store and 9.3 feet east of most eastward coconut palm of three palms in east and west line. Bench mark consists of 5-inch stovepipe filled with cement, with galvanized lag screw in center of top. Top is 3 inches above surface of ground.



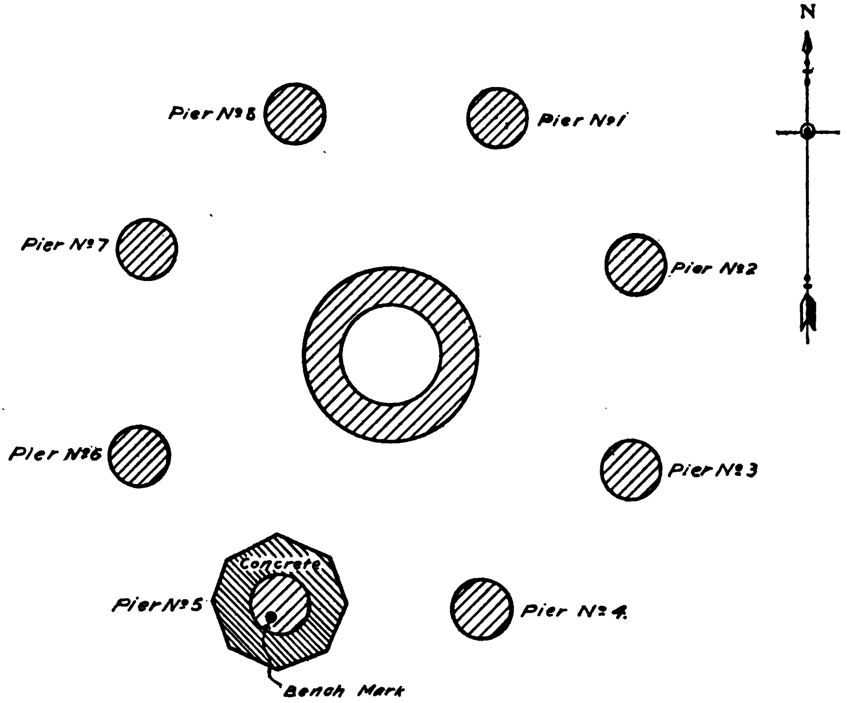
Place.—Canal at Delray, Fla.
Designation.—Florida intracoastal bench mark No. 41.
Elevation.—6.289 above mean low water, Fernandina.
Description.—Consists of a 5-inch stovepipe filled with cement, with galvanized spike in center of top. Lettered U.S.B.M. Top of bench mark, 4 inches from surface of ground. Situated 512 feet east of intersection of Dade Street and Atlantic Avenue, 23 feet south of I. H. Burton's residence, 8 feet east of coconut palm.



Place.—Lake Wyman, Fla.
Designation.—Florida Intracoastal bench mark No. 42.
Elevation.—5.534 above mean low water, Fernandina.
Description.—Situated 4 feet south of southwest corner of Thomas Peters's house, opposite about center of Lake Wyman, on west shore. Bench mark consists of a stovepipe filled with cement, with 60d. galvanized round nail inserted; head of nail just above cement.

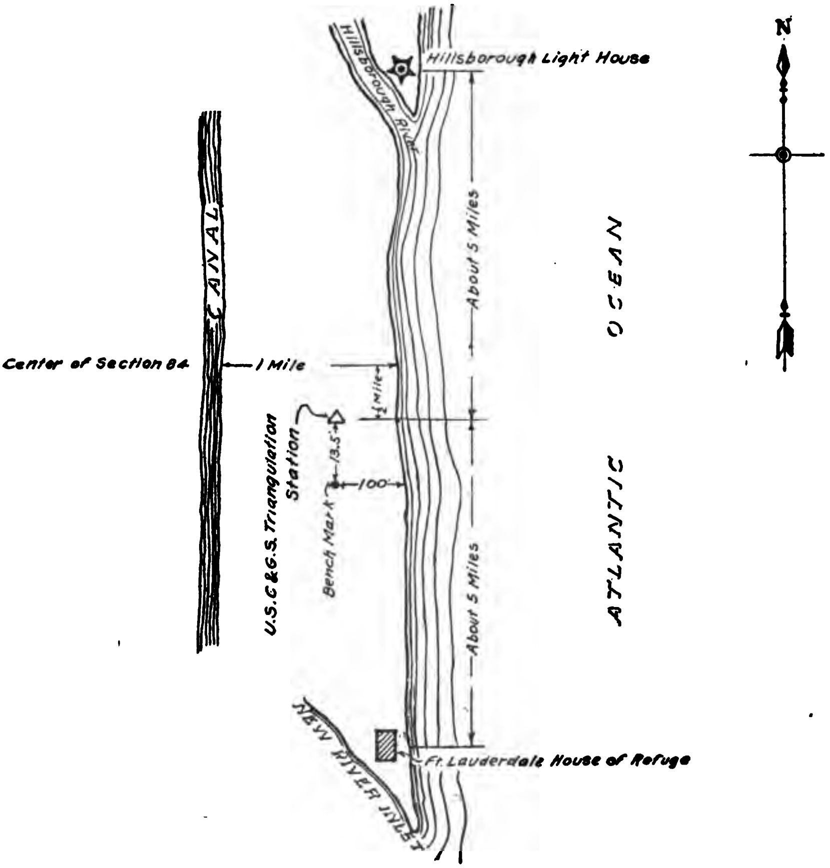


Place.—Hillsborough Lighthouse, Fla.
Designation.—Florida Intracoastal bench mark No. 43.
Elevation.—11.869 above mean low water, Fernandina.
Description.—Located on top of southwest anchorage, bolt in pier on south side of light at Hillsborough Inlet. This pier being the first pier west of a north and south line extending through center of light.

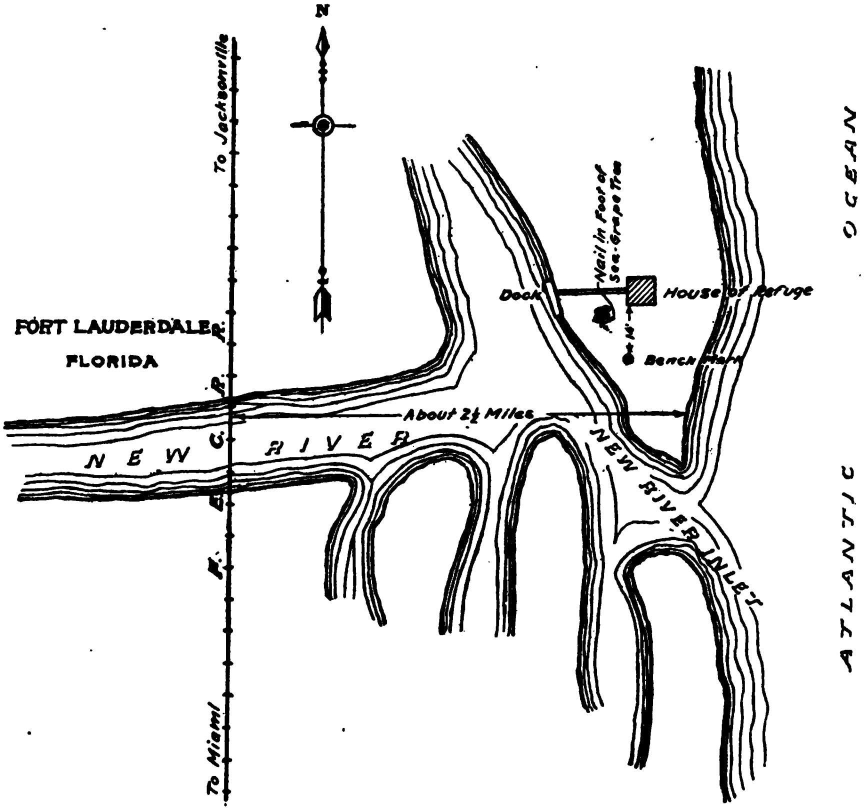


HILLSBOROUGH LIGHT HOUSE
FLORIDA

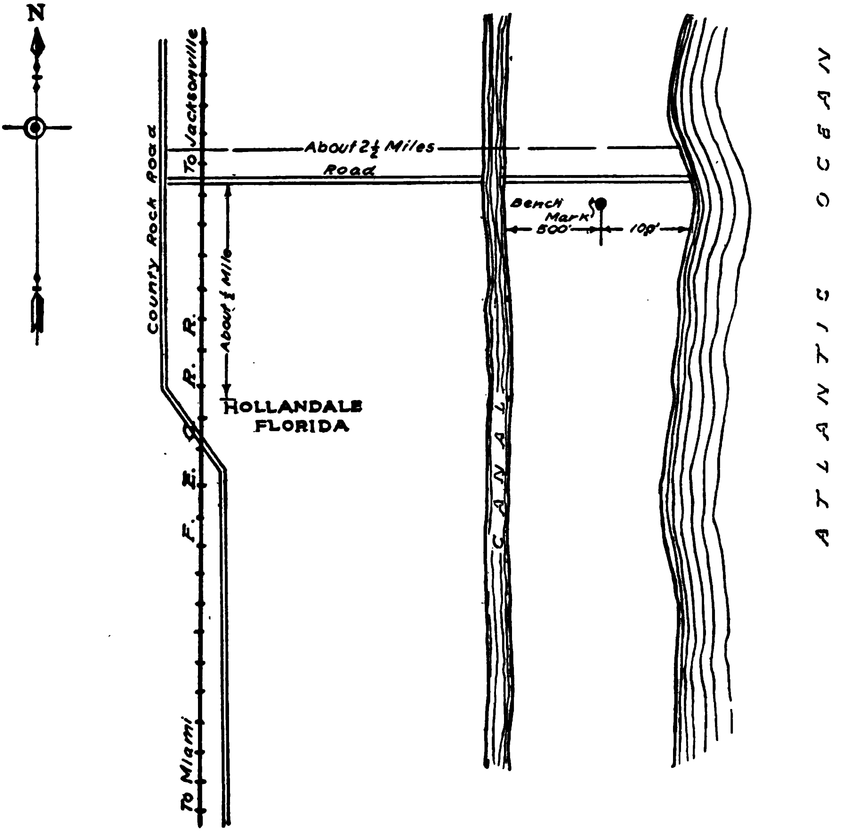
Place.—Between Hillsborough Lighthouse and Fort Lauderdale.
Designation.—Florida Intracoastal bench mark No. 44.
Elevation.—13.234 above mean low water, Fernandina.
Description.—Located at middle of canal section 84, 13.5 feet south of Coast and Geodetic triangulation station. Situated on sand ridge 100 feet from beach and about 5 miles south Hillsborough Lighthouse. Bench mark consists of stovepipe filled with cement with 60d. galvanized round nail inserted. head of nail just above cement.



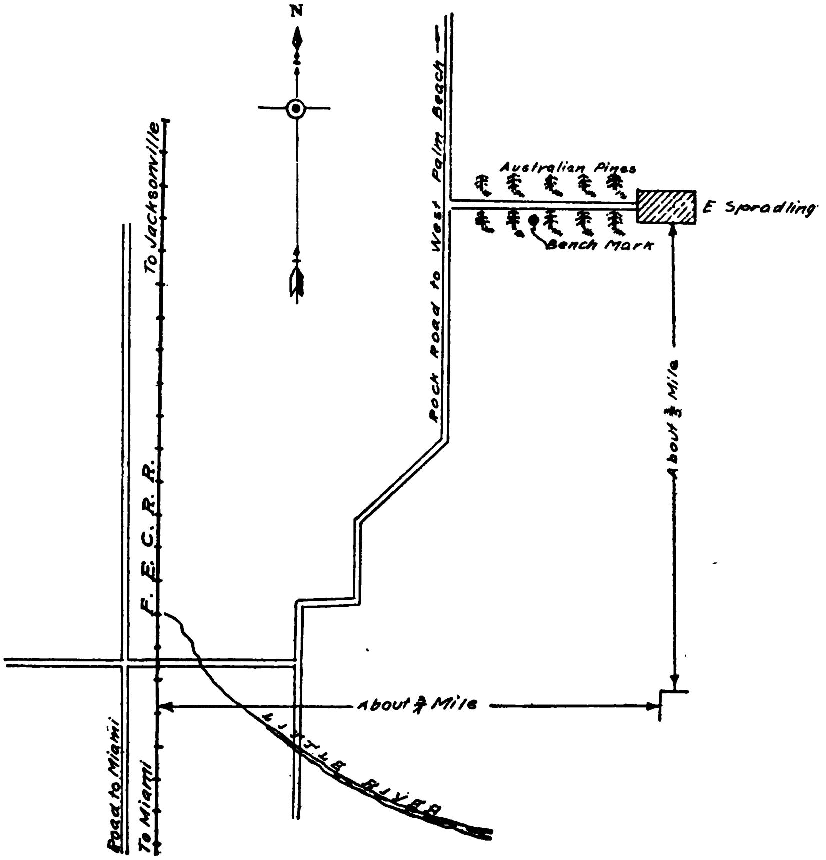
Place.—New River Inlet near House of Refuge.
Designation.—Florida Intracoastal bench mark No. 45.
Elevation.—10.163 above mean low water, Fernandina.
Description.—Located 14 feet south of southwest corner of House of Refuge near New River Inlet. Bench mark consists of stovepipe filled with cement with 60d. galvanized round nail inserted, head of nail just above cement.



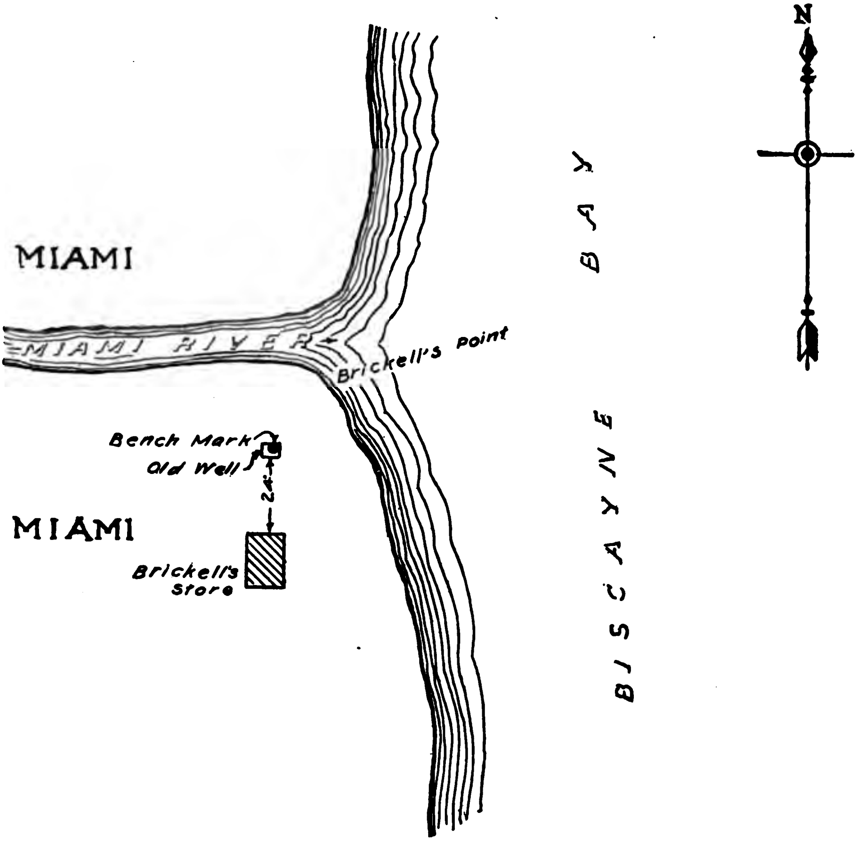
Place.—Hallandale Beach Road.
Designation.—Florida Intracoastal bench mark No. 46.
Elevation.—12.744 above mean low water, Fernandina.
Description.—Consists of a stovepipe filled with cement, with 60d. galvanized round nail inserted, head of nail just above cement. Bench mark is situated on sand bank between canal and beach, about 100 feet from ocean, just outside of Hallandale Beach Road. Bench mark taken on top of nail referred to above.



Place.—Biscayne Bay about three-fifths mile north of Little River.
Designation.—Florida Intracoastal bench mark No. 47.
Elevation.—9.109 above mean low water, Fernandina.
Description.—Top of nail placed in concrete monument. Monument made by placing concrete in a joint of stovepipe. Bench mark is located about three-fifths of a mile north of Little River, between second and third pine trees, on south side of avenue leading from rock road to Spradling's residence. Pine trees being counted from intersection of rock road and avenue leading to Spradling's residence.



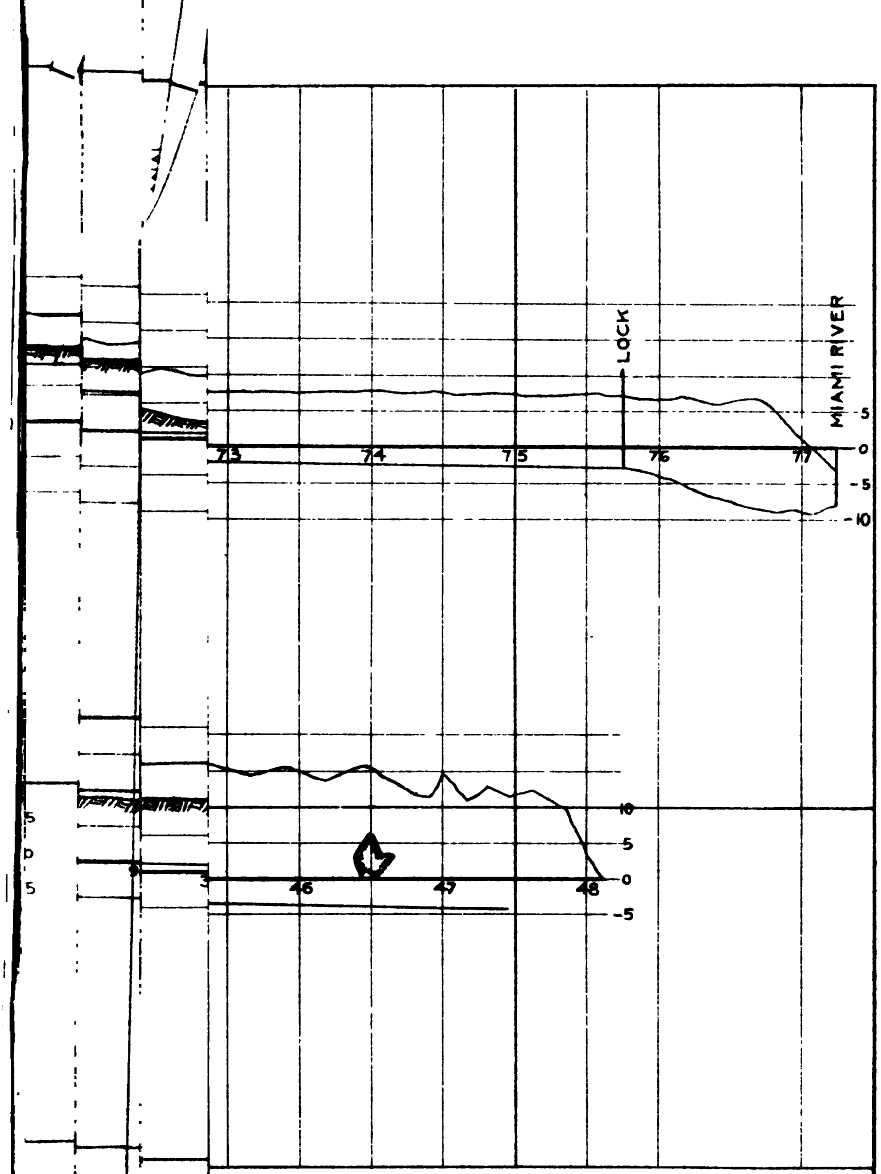
Place.—Biscayne Bay at Miami, Fla.
Designation.—Florida Intracoastal bench mark No. 48.
Elevation.—10.978 above mean low water, Fernandina.
Description.—Spike in old well, 24 feet north of Brickell's store at Miami, Fla.



APPENDIX D.

PROFILES.

Loxachee Slough to Lake Okechobee. United States Department of Agriculture.
Fort Myers to Pompany, via Immokalee. United States Department of Agriculture.
Fort Myers to Pompany, via Travers Home. United States Department of Agriculture.
Lake Okechobee to Brown's store. United States Department of Agriculture.
Hillsborough line, east and west Government Road. United States Department of Agriculture.
Peters Prairie to Bay Biscayne. United States Department of Agriculture.
South lines secs. 2 and 3, T. 56 S., R. 40 E. United States Department of Agriculture.
Black Point Creek. United States Department of Agriculture.
Stuart to Lake Okeechobee. United States Army Engineers.
Caloosahatchee River. United States Army Engineers.
Kissimmee River. United States Army Engineers.
Waterway Kissimmee to Lake Okeechobee. United States Army Engineers.
West Palm Beach to Lake Okeechobee. Florida Everglades Engineering Commission.
Detroit to Hammer Key. Florida Everglades Engineering Commission.
Brown's store to Chokoloskee. Florida Everglades Engineering Commission.
Miami to west line Dade County (Fredricks). Florida East Coast Railroad Co.
Mile post 261 to mile post 415. Florida East Coast Railroad Co.
Each one-half mile west of track and south of Detroit. Florida East Coast Railroad Co.
South Fork, St. Lucie River to Lake Okechobee. Everglades drainage district.
Lake Worth to Lake Okechobee. Everglades drainage district.
West Palm Beach Canal. Everglades drainage district.
Hillsborough Canal. Everglades drainage district.
North New River Canal. Everglades drainage district.
Miami Canal. Everglades drainage district.
South New River Canal. Everglades drainage district.
Snake Creek Canal. Everglades drainage district.
Snapper Creek Canal. Everglades drainage district.
Cypress Creek Canal. Everglades drainage district.
Detroit Canal. Biscayne Engineering Co.
Royal Glade Canal et al. Everglade Land Sales Co.

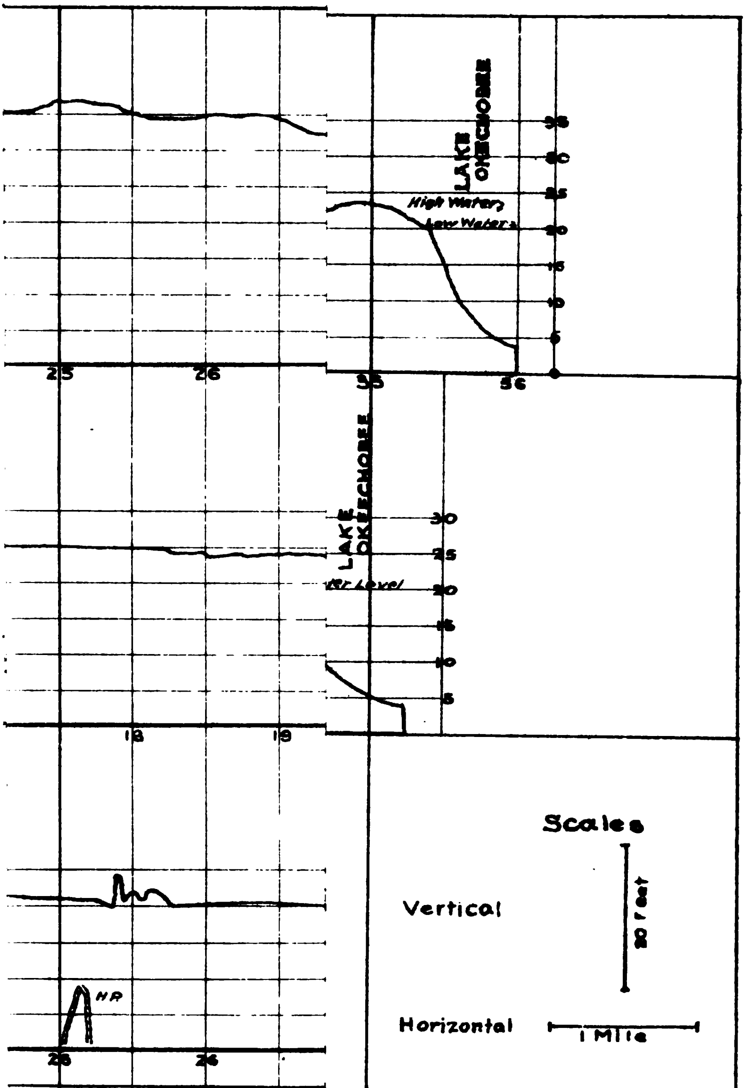


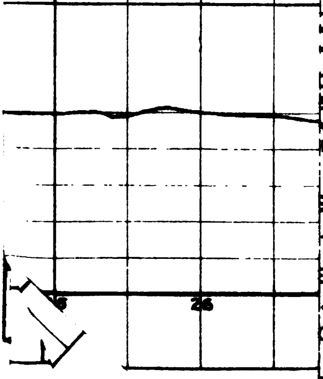
PROFILES

MIAMI CANAL
SOUTH NEW RIVER CANAL
HILLSBORO CANAL
NORTH NEW RIVER CANAL
Accompanying Report of
ORIDA EVERGLADES ENGINEERING COMMISSION
To The
USTEES OF THE INTERNAL IMPROVEMENT FUND
of the
STATE OF FLORIDA

October 1913

Senate Doc. No. 379; 63d Cong., 2d Sess.





OFILES

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ANAL—LAKE OKEECHOBEE
RIVER—LAKE OKEECHOBEE
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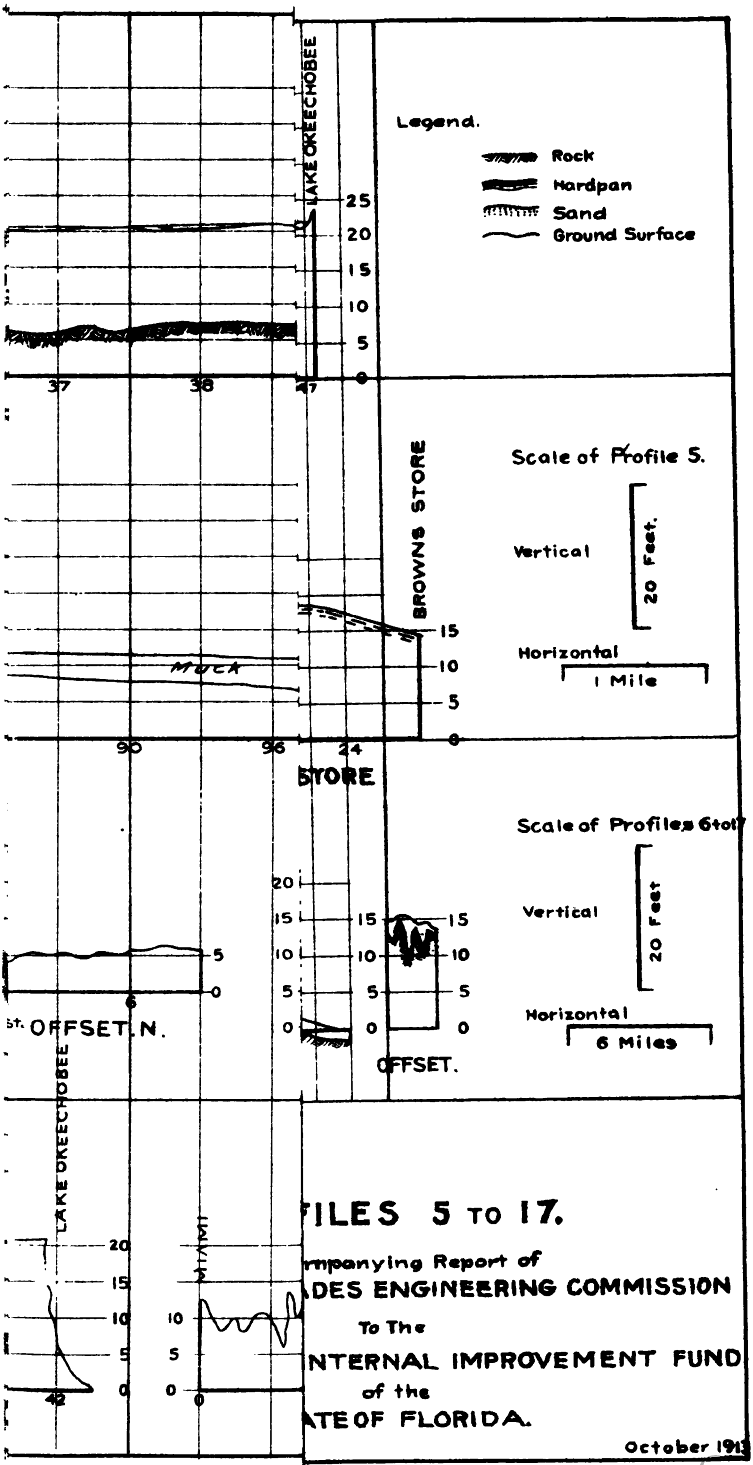
S ENGINEERING COMMISSION
To The
ERNAL IMPROVEMENT FUND
of the
OF FLORIDA

October 191

379; 63d Cong., 2d Sess.



FILES 5 TO 17.

mpanying Report of

DES ENGINEERING COMMISSION

To The

NTERNAL IMPROVEMENT FUND

of the

ATE OF FLORIDA.

October 1913

o. 379; 63d Cong., 2d Sess.

APPENDIX E.

BIBLIOGRAPHY.

It does not seem to us necessary, or even desirable, to burden this report with historic records, however much the story of Florida and the Everglades might add in popular interest to the dull recital of facts which we have gathered and upon which we have formed our conclusions and based our recommendations as hereinbefore set forth. But we make slight reference to several sources of information which are readily accessible and interesting, viz:

A Report on the Florida Everglades by John T. Stewart, Professor of Agricultural Engineering, University of Minnesota, formerly of the Office of Experiment Stations, United States Department of Agriculture.

"Report on the Drainage of the Everglades of Florida" to the Everglade Land Sales Co. by Daniel W. Mead, Allen Hazen, Leonard Metcalf.

Senate Document No. 89, Sixty-second Congress, first session, 1911, "Everglades of Florida."

Forty-three pamphlets on the "Everglades of Florida," containing the testimony and discussions before the "Committee on Expenditures in the Department of Agriculture," United States Congress, extending over the period between February 3 and August 9, 1912.

Report of W. H. Caldwell, United States Assistant Engineer on the "Kissimmee Waterway," published in Chief Engineer's Report, United States Army Engineers, 1912.

Authorization of Robert Shaw Oliver, Assistant Secretary of War, 29th of May, 1912, for connection of four canals—South New River (now Miami), North New River, Hillsborough, and West Palm Beach—with Lake Okeechobee.

"Instructions for Surveying Everglades Lands" adopted by Trustees of Internal Improvement Fund of the State of Florida and amended instructions for same.

Report of State Chemist (Florida) "Everglades Soils," 1912.

Report on lands in vicinity of White Water Bay, N. Barco, 1912, to Trustees of Internal Improvement Fund.

Lieut. Col. Q. A. Gilmore, Corps of Engineers, made a report on a survey made with a view of opening a steamboat communication from the St. Johns River via Tohopekaliga to Charlotte Harbor on Pease Creek. Senate Document 187, Forty-seventh Congress, May 23, 1882.

"Memoir to accompany a Military Map," J. C. Ives, United States Topographical Engineer, published by the War Department in April, 1856.

The St. Augustine Institute of Science and Historical Society, St. Augustine, Fla., Dr. DeWitt Webb, president, has maps and publications relating to the Everglades of much interest.

APPENDIX F.

PHOTOGRAPHS PERTINENT TO THE EVERGLADES OF FLORIDA.

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High-water mark, Labelle, Caloosahatchee River 123
Heavy saw grass, Everglades 124
Cabbage Palm 125
Okeechobee entrance to South New River 126
High water, Caloosahatchee River 127
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South New River Canal 129
View on South New River Canal 130
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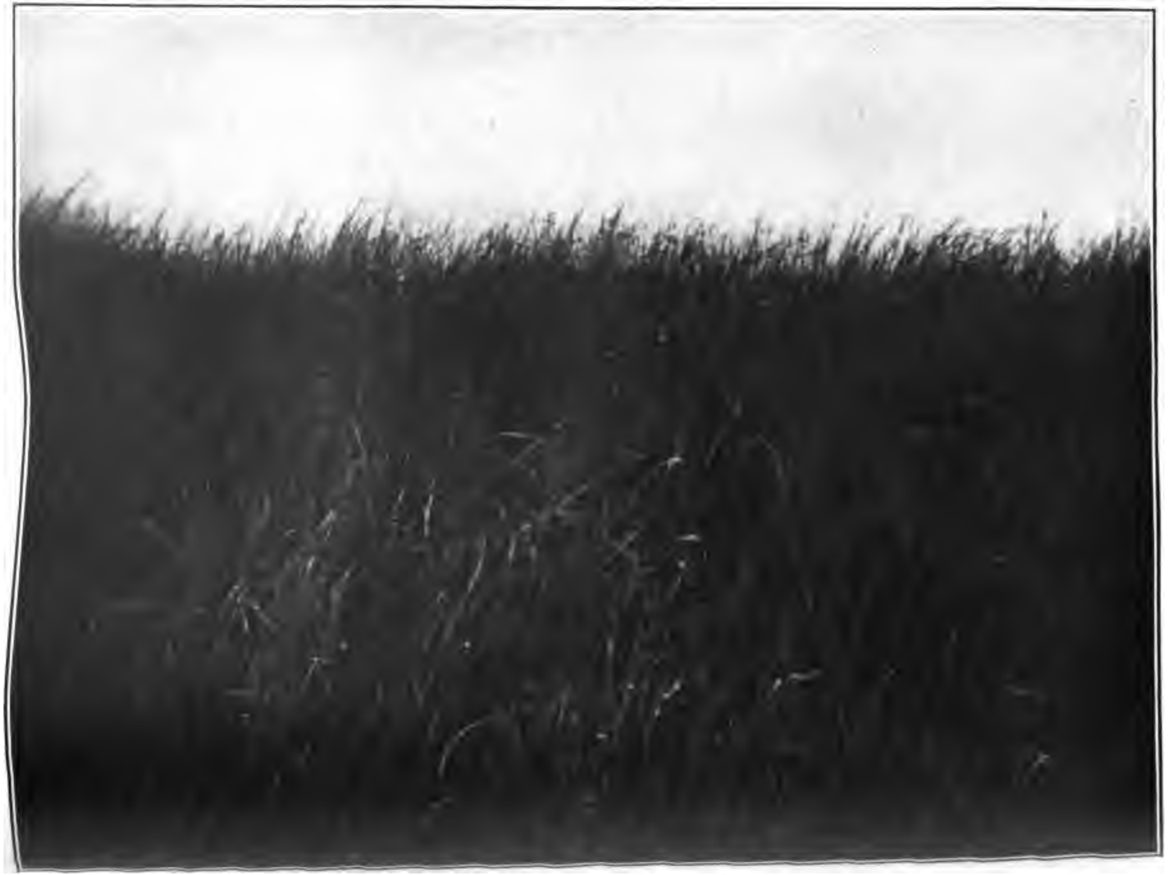
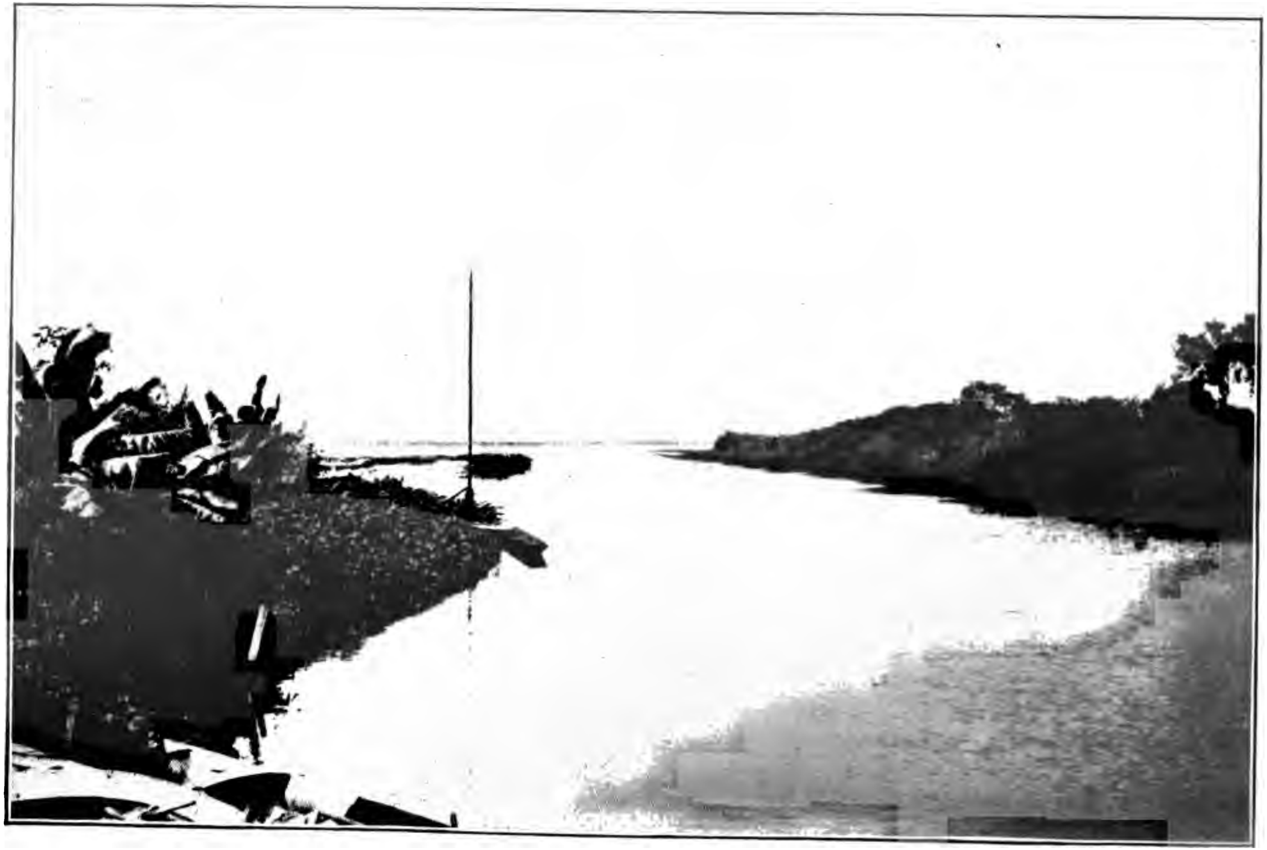
Seminole Indian hunting in Everglades 143

HIGH-WATER MARK, LABELLE, CALOOSAHATCHEE RIVER.

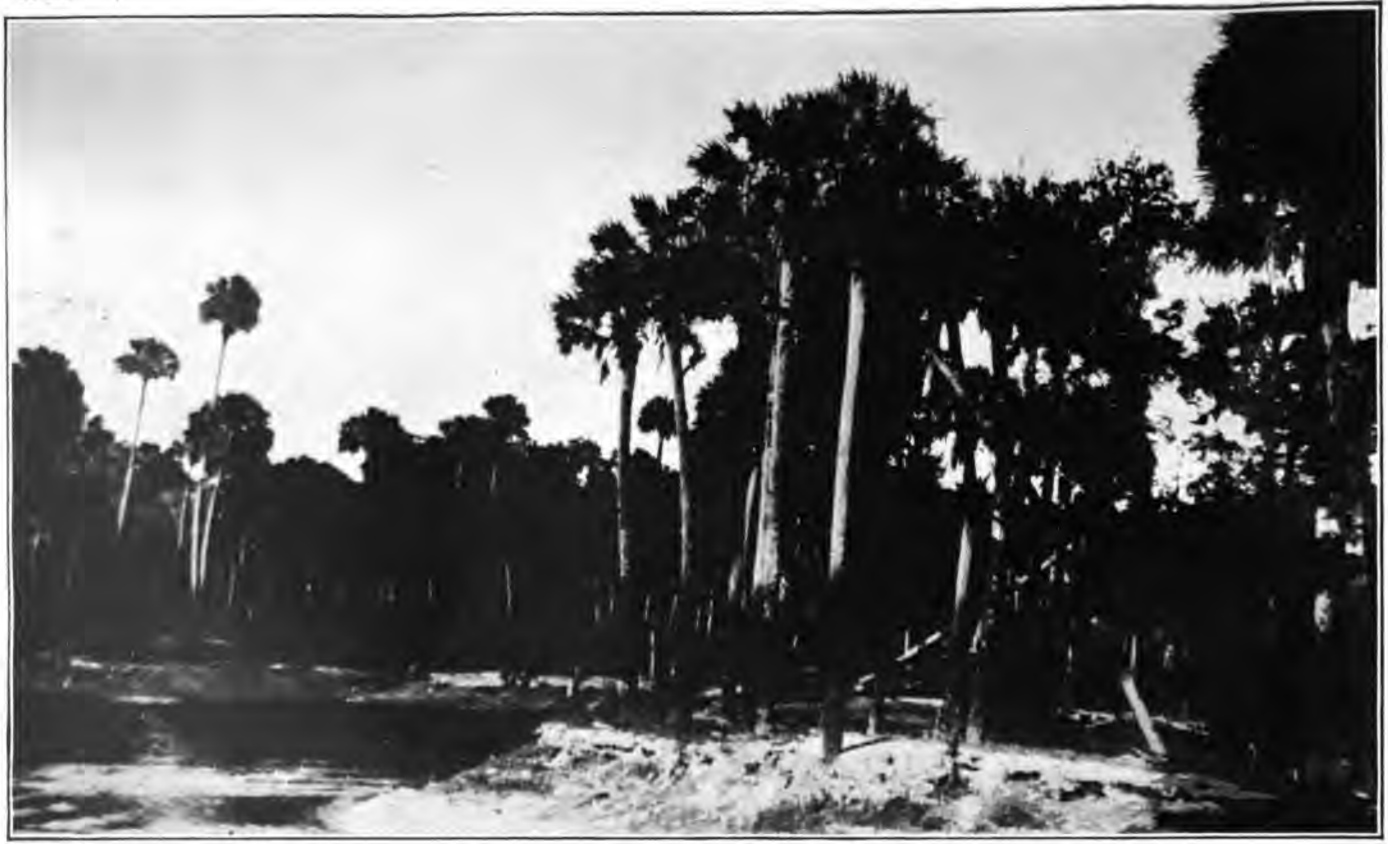


HEAVY SAW GRASS, EVERGLADES.

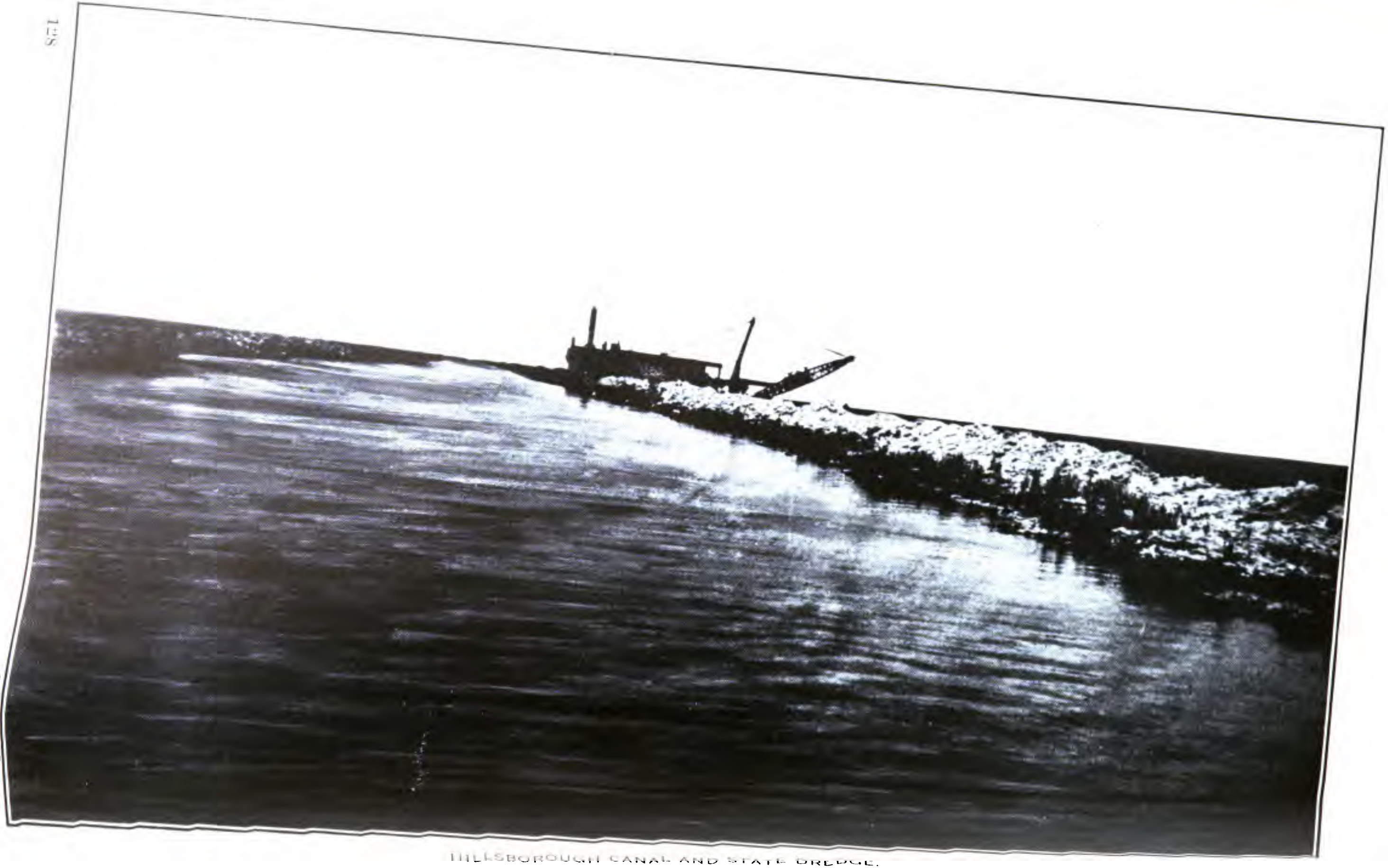
CABBAGE PALM.



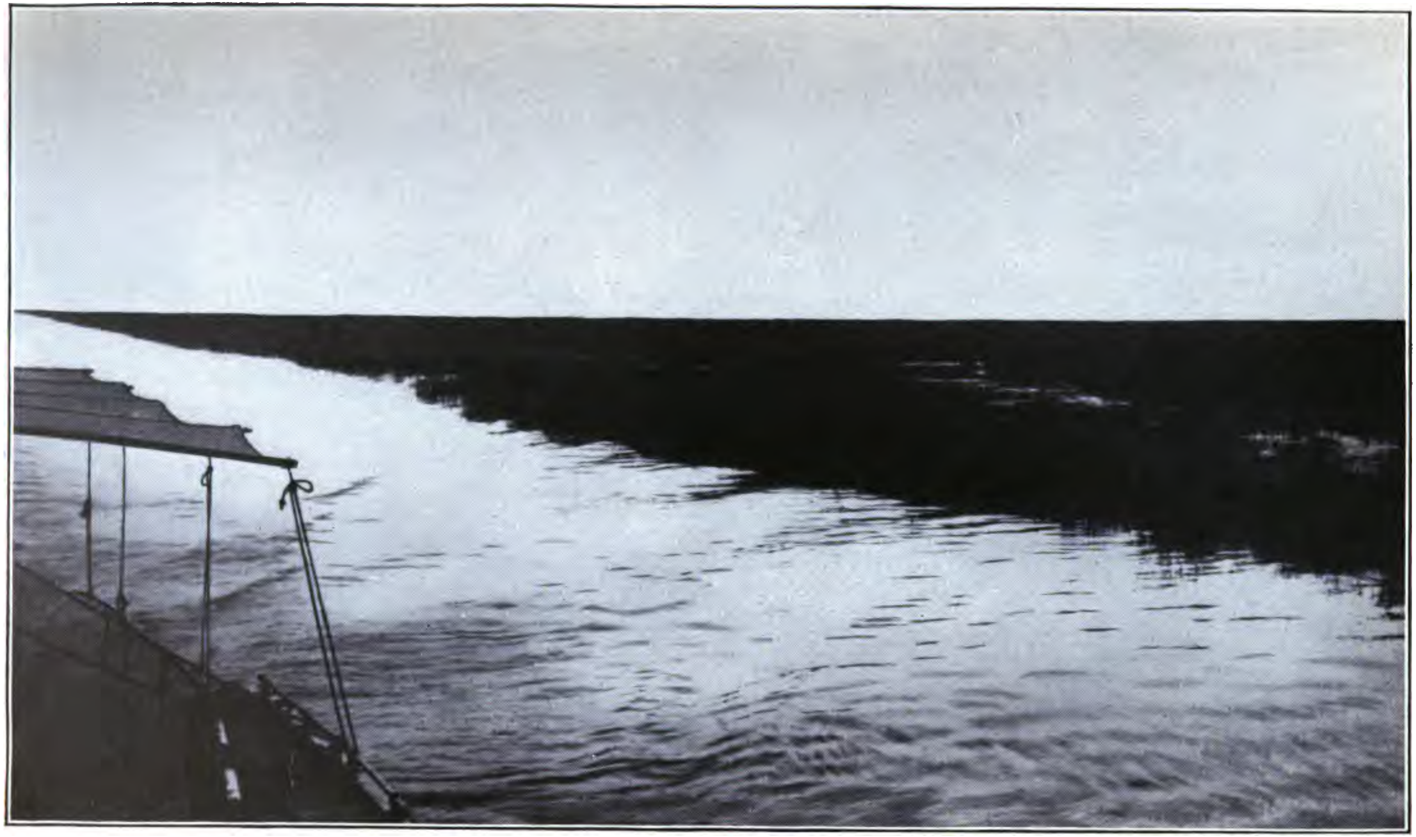
OKEECHOBEE ENTRANCE TO SOUTH NEW RIVER.



HIGH WATER, CALOOSAHATCHEE RIVER.



HILLSBOROUGH CANAL AND STATE DREDGE.

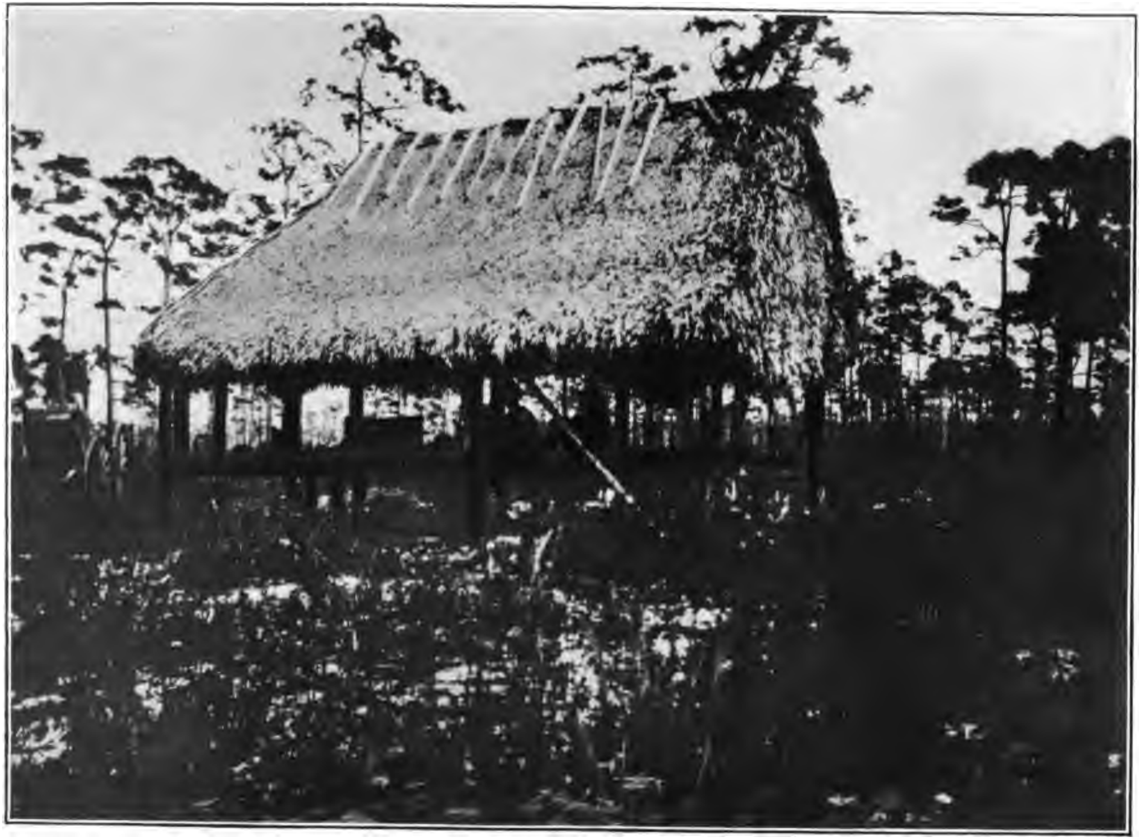


SOUTH NEW RIVER CANAL.

VIEW ON SOUTH NEW RIVER CANAL.

GAUGING STATION ON NORTH CANAL.

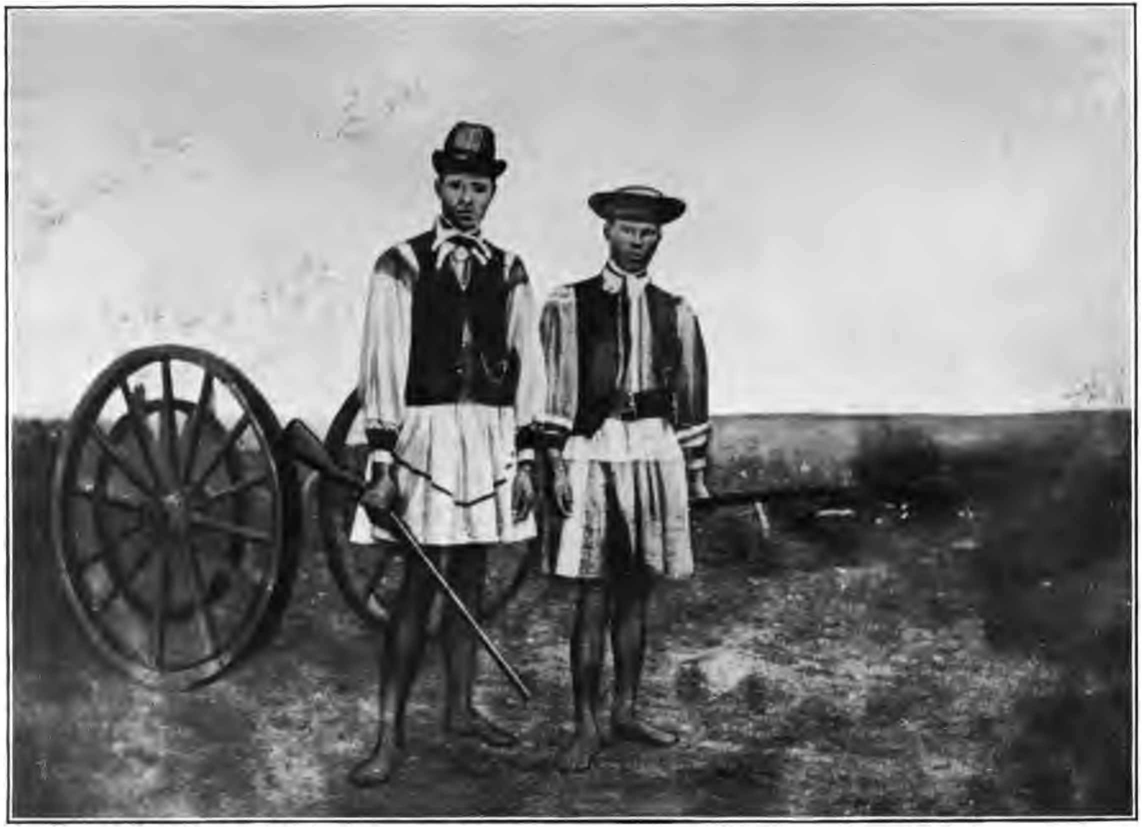
OPEN "GLADES," NORTH NEW RIVER CANAL.



SEMINOLE INDIAN DWELLING.

S. Doc. 379, 63-2.

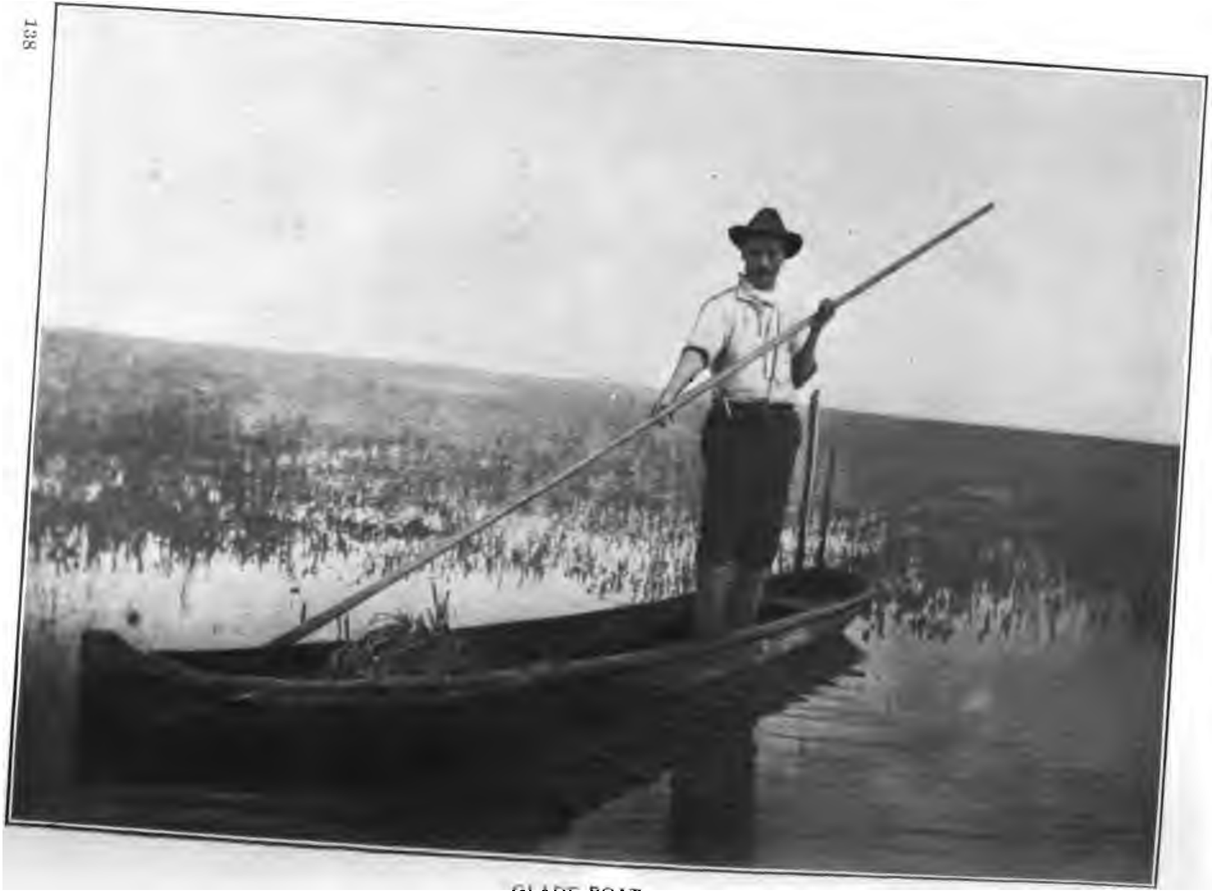
CROSSING THE EVERGLADES.



SEMINOLE INDIANS.

EAST SIDE OF EVERGLADES.

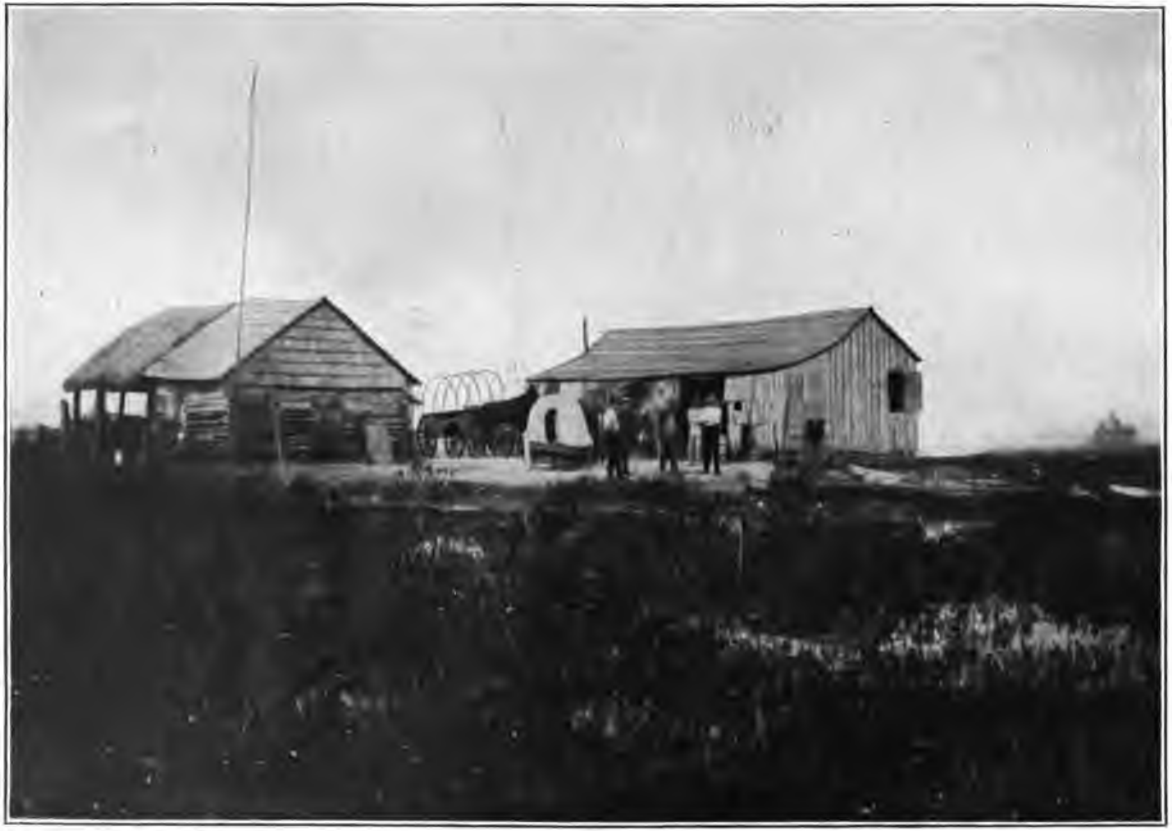
RECONNOISSANCE.



GLADE BOAT.

HILL SURVEY PARTY.

EVERGLADES SURVEY PARTY.



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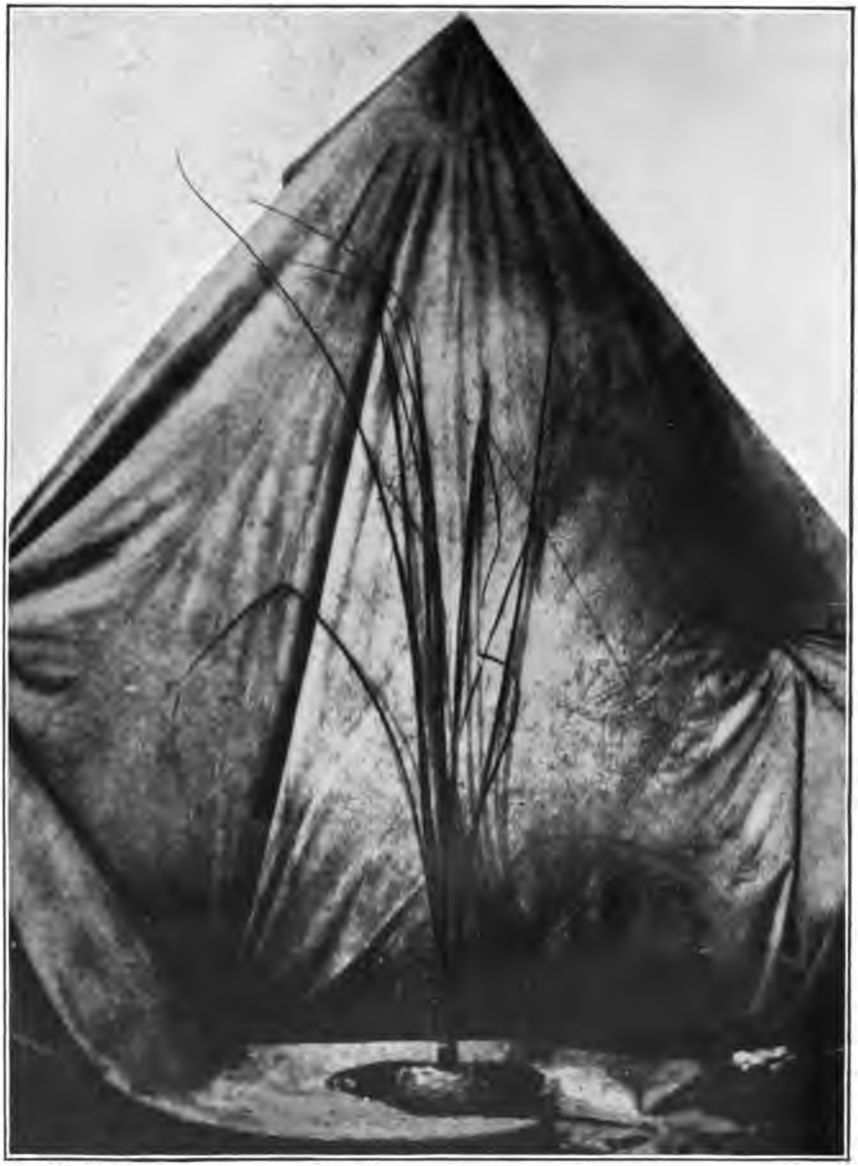

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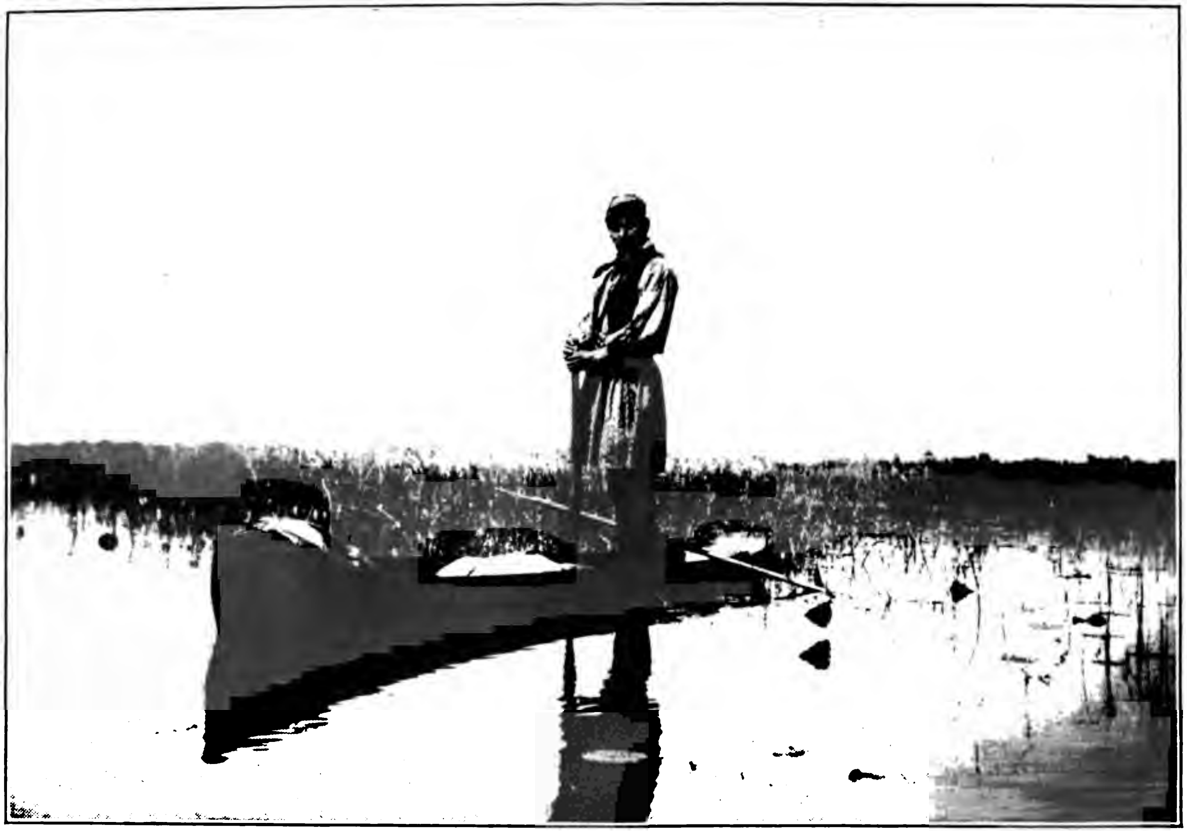

SEMINOLE INDIAN HUNTING IN EVERGLADES.

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